NYANKPALA AGRICULTURAL EXPERIMENT STATION

WORKSHOP ON IMPROVING FARMING SYSTEMS IN THE INTERIOR SAVANNA ZONE OF GHANA

PROCEEDINGS

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A Profile Of
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Experiment Station

The Nyankpala Agricultural Experiment Station (NAES) is part of the Crops Research Institute (CRI), one of 12 institutes within the Council for Scientific and Industrial Research (CSIR), an autonomous organization within the Ministry of Industries, Science and Technology of the Republic of Ghana.

Financial and technical support to the station is provided by the Ghana Government and the Federal Republic of Germany through the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. and the French International Centre for Research in Tropical Agriculture (CIRAD).

The station's mandate is to develop sustainable cropping systems adapted to the needs of farmers in the different ecological zones of northern Ghana and to improve the crop varieties grown in the zone (maize, rice, sorghum, millet, cotton, yams, cassava and various grain legumes).

Nyankpala Agricultural Experiment Station is located 16 km west of Tamale in the Interior Savanna Zone of Ghana. With one rainy season from April to October, it receives about 1000 mm of rainfall annually. Altitude is approximately 200 m above sea level.

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PROCEEDINGS

Nyankpala Agricultural Experiment Station, GHANA.

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CROPS RESEARCH INSTITUTE
(CRI)

DEUTSCHE GESELLSCHAFT FÜR TECHNISCHE ZUSAMMENARBEIT
(GTZ)

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Topic: Preservation of the environment under increased agricultural productivity in the Savanna Zone.

Panelists: Prof. D.K. Acquaye - University of Ghana, Legon (CHAIRMAN)
Dr. H. Rudat - Project Manager, NAES
Mr. H. Mercer-Quarshie - Co-Project Manager, NAES
Mr. S.Y. Anane - Reg. Director, MoA
Mr. S.A. Gumah - Private Farmer
Dr. S.A. Botwey - IFAD SRDP Programme Director
Mr. E.A. Addison - Director CRI
Mr. J.K. Wumnaya - Director, MoA, UER
Mr. M.K. Ansah - Director of Extension Services, MoA, Northern Region

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P r e f a c e

The problem of inadequate agricultural production particularly in the Interior Savanna Zone remains unsolved. Since the last workshop in 1986, the rate of population growth in the interior savanna still hovers around three percent. While reports show that agricultural production in Ghana increased in the late 80s this was only apparent in years of adequate rainfall. In years of either over abundant rainfall such as 1989 or inadequate rainfall, production plummeted. Meanwhile subsidies on fertilizer and agro-chemicals have been abolished resulting in diminished ability of farmers to purchase required inputs. Again imports have been deregulated resulting in an influx of low-priced food products which have made local production uncompetitive and rendered farmers very much worse off.

Some farmer practices which reduce the fertility and therefore the productivity of soils such as indiscriminate bush burning and overgrazing of animals continue to be the norm.

To extricate the farmer from the vice of problems in which he finds himself, development and use of options/ technologies which improve productivity but are affordable and conserve the production base are required.

Meanwhile many sponsored projects have been established or are in the process of being established whose activities, if not harmonized, may waste resources.

The foregoing shows that the objectives set in 1986 are still relevant. The 1990 workshop was to identify the major constraints to agricultural production, formulate research priorities, share information on available options/technologies and initiate the process of harmonizing various research activities being implemented in the Interior Savanna Zone.

Attendance in this second workshop exceeded 200 participants including policy makers, farmers, extension agents, researchers, university and agricultural college teachers, students, bankers and dealers in agricultural inputs. In addition to discussions on scientific papers a panel discussion was held on "Preservation of the environment under increased agricultural productivity in the savanna zone". The conclusions reached are published herein.

The NAES wishes to acknowledge the financial support given by Chemico, BASF Company and Agro-machinery and Chemical Distribution Ltd. the only companies that responded positively amongst many that were approached for help.

We wish to express our gratitude to Col I.B Commey, PNDC Secretary of the Ministry of Industries, Science and Technology and Mr. Ibrahim Adam, PNDC Deputy secretary, Ministry of Agriculture who gave the main addresses.

H. Mercer-Quarshie
Station Manager

Dr. Hans Rudat
GTZ, Team Leader

Welcome Address - Dr. H. Rudat, Project Manager, NAES

Ladies and Gentlemen,
My function here today is twofold:
- To welcome you and
- To introduce the chairman for this opening session.

In the name of the entire station, my colleagues and myself, we welcome you to Nyankpala to the 2nd National Workshop on Improving Farming Systems in the Savanna Zone of Ghana. It is a great pleasure and honour for us to have you here.

A special warm welcome to our
- PNDC Secretary for Industries, Science and Technology, Col. R.B. Commey, who has travelled all the way up to this beautiful place Nyankpala. We also welcome the
- PNDC Deputy Secretary for Agriculture, Eastern Region, Dr. Ato-Quarshie, and Mr. Ibrahim Adam, Deputy Secretary for agriculture (Crops) who is deputizing for the PNDC Secretary Commodore (Rtd) Steve Obimpeh, who was not able to come. We also welcome the
- PNDC Regional Secretary of Northern Region, Mr. John Bawa and the
- PNDC Deputy Regional Secretary, Agriculture, NR, Mr. Adam Kaleem.

We want to welcome the representatives of the Ministry of Agriculture from NR, UW and UE, representatives of universities, other research stations, the banks, the chemical industry - the latter two having supported us financially to help realise this workshop, for which we are grateful.

A special welcome goes to our Director of the CRI - head-quarters in Kumasi, Mr. E. A. Addison,

We also want to welcome distinguished scientists of regional and international institutes and organizations which I think are indispensable in an event like this one.

We greet all our colleagues, scientists and extensionists and the farmers who are taking part in this 3-day gathering.

I have to apologise for the absence of the West German Ambassador. He has travelled outside the country.

Last, we have to express our sincere thanks to the principal of the Nyankpala Agric. College, Mr. N. K. Adjei, for letting us use this hall. Without this, such an event would not have been possible here in Nyankpala.

As you are all aware, the NAES - as a branch of the CRI - has a long history, going back to the late forties. Since 1977 a cooperation between Ghana and Germany began in order to upgrade this station, to be able to respond with a multidisciplinary research approach to the manifold problems of northern Ghana's agriculture. Northern Ghana where about 40% of the land area of the country is, is demarcated into three administrative regions from which is produced more than 50% and 60% of the nations cereals and legumes, respectively.

Twelve years ago, when ground was broken for the new development of the station the wish and desire of both the Ghanaian and German sides was that this station should look into 3 principal aspects of agriculture, namely:

- the development of suitable cropping systems which could fit into improved Farming Systems in our mandate area,

- the improvement of crops being grown here and

- the improvement of agronomic practices of our farmers.

To realise this ambition, it was necessary to build up the infrastructure and equip the station. After this, research work started in 1980. Today, 30 scientists from 3 nations are employed at NAES to carry out activities in even more than the above mentioned fields. As an international community we have surmounted many problems in the past linked with limited budgets, shortage of personnel and setbacks of our technical infrastructure, e.g. electricity, water, roads, to name just a few. With the wise guidance of Kwadaso - our headquarters - however, we have overcome most of the shortfalls.

On the Ghanaian side - since the beginning of our work - there was and still is one man behind the successful development of this station. With a strong will, intelligently he has put the strings of this station together. I would like to name our Co-manager, *Mr. Mercer-Quarshie* who, with his never tiring spirit has brought this station to its scientific standard today.

I also have to mention our present regional administration headed by our Regional Secretary, and his Deputy Secretary for Agriculture and the Director of the Ministry of Agriculture. They have constructively helped this station with their open and critical participation and suggestions.

After 10 years of solid work in the field of crop improvement and on our main research activities in the

Farming Systems Department we are aware that working with agricultural problems in the savanna zone is a tedious job. Quick results and solutions to the problems in our harsh environment with fragile soils do not readily exist because of the complexity of the problems. We are sure that the times of the 'Green Revolution' are long over. In our present rural society it is not only a question of a new variety, fertilizer application and irrigation to increase the overall agricultural output as some people might still believe. The lack of better varieties for different crops in our farming systems, the lack of new and adapted technologies/options for our farmers, the lack of credit facilities and basic needs like water, electricity, roads, schooling, medical care etc. indicate that progress in agricultural development today can only be seen as a long evolutionary process - a thorny though rewarding way.

In this context, I wish to add one more idea. As agricultural development is a very complex undertaking, agricultural activities normally do not only include crop production but also animal production, agricultural mechanization and training of the rural population. The Ghana Government in the past had an ideal set-up of these elements here at Nyankpala. The station is looking forward to the day when animal husbandry and agricultural mechanization might be revived and the agricultural college - which we are just using for our purpose - upgraded, to foster even more agricultural development in future.

After a period of four years since our 1st Farming Systems Workshop, we want again to share our results and ideas with others and we are glad that so many of you accepted our invitation to this workshop. In 1986 our emphasis was on "Bottlenecks of rapid agricultural development in Northern Ghana and possible remedies". I think, we are still faced with many bottlenecks and we also have not found all remedies yet. This time the workshop is emphasizing the "Preservation of the environment under increased agricultural productivity in the savanna zone". Those who are dealing with agricultural research and/or development know that this is a tremendous task and responsibility we want to contribute to. We think we have no choice because our environment is constantly being destroyed through the careless or unconscious activities of men in various positions. Because of these alarming developments around us, we at the station are undertaking new elements of research which deal with agroforestry, mulching and manuring of our soils, improved tillage methods and other means to maintain and improve soil fertility and reduce destruction of this basic property.

We hope to learn during the coming days from our colleagues how they see the problems and the possible solutions to them. I am very keen to hear, what new ideas they can give us as a research station in order to understand better our fragile environment and our farmers under an increased productivity.

Once again I have to apologise. We wanted to be ready with the proceedings of our 1st workshop but due to the change of the German administration last year we were faced with too many hurdles to bring the proceeding out in due time. We will have a list ready during the workshop, so interested participants can sign for the proceedings, which hopefully will be out by July of this year, latest.

Ladies and gentlemen,
Allow me to emphasize one last point. I still remember the seminar on Research - Extension linkages which was held last year in Accra and was organised by the Ministry of Agriculture. From the station's point of view we have tried to bridge the gap between ourselves, the research side, and the extension and NGO's since the last couple of years, through two vital sections which we call "Liaison" and "On-Farm-Experimentation". Both units help us to open the station to the end users of our products. In addition to that, Ministries and NGO's are represented in two decisive bodies of our station namely, the 'Steering Committee' and the revitalized 'Research Committee'. For a research station in Ghana this is not a common procedure, but we think these are indispensable tools if we want to communicate with user agencies and decision makers of agricultural development in this country.

A clear manifestation of this integration of research and extension is an 'Agricultural Extension Bulletin' published by NAES together with the three Ministries of Agriculture of the three northern regions which we want to launch today during the opening session of the workshop.

Before I call on our Regional Secretary, Mr. John Bawa, to chair this opening session I want to thank you once again for coming and I wish all of us fruitful discussions.

Please, honourable Regional Secretary, may I invite you to chair this first session for us. Thank you!

H. Rudat

Special Address by Col. I. B. Commey, The PNDC Secretary for Industries, Science and Technology, at the Opening Session of the 2nd National Workshop on Improving Farming Systems in the Savanna Zone of Ghana, 24th April, 1990.

Honourable PNDC Secretaries,

Distinguished Guests,

Workshop Participants ,

Ladies and Gentlemen.

I am very happy to be with you today on the occasion of the opening of this important workshop. Since assuming office I have been looking forward to visit the north and especially Nyankpala. This is because when I survey the country, the vast expanse of the savanna promises to have a potential which can be unravelled only with a thorough research effort the likes of which is now being done at Nyankpala. Nyankpala station represents for me a spectacular example of what science and technology can do for the savanna zone.

In 1977 when the constructional phase of the Nyankpala Agricultural Experiment Station (NAES) project started only one scientist was on the station. Today, there are thirty scientists including ten expatriates. Whereas the one scientist concentrated his efforts on weed control measures, today there are programmes on crop improvement in sorghum millet, maize, rice, groundnut, cowpeas and soya beans. There are farming systems programmes which seek to integrate environmental enhancement for crops developed with socio-economic acceptance. There is development at NAES a unique on-farm research activity which brings together researchers, extension agents and farmers enabling real and genuine concerns of farmers to be researched into and serving as a channel for pre-informing farmers of emerging technologies.

Ladies and Gentlemen,

Through on-farm trials conducted by researchers, extensionists and farmers together, improved varieties of sorghum Framida and NSV-1, improved varieties of rice, GR 19 and GR 21, improved variety of cowpea, Valenga, and that of groundnut, F mix have been adopted by farmers in the region. Even for a crop like soya bean recently introduced by NAES, improved varieties, Salintuya 1 and 2, are eagerly sought after.

The station has made the centrepiece of its strategy, the development of technologies which require low external input and therefore are sustainable by small farmers. In

this regard it is gratifying to note that technologies such as crop rotations of legumes, cereals and root crops which make for soil fertility maintenance and stable yields, the cultivation of short-season legumes before cereals to reduce weed infestation in cereals and also increase soil fertility, the use of vegetation from established bushy legumes as mulch for adjacent cereal crops to supply nitrogen and organic matter and also protect the soil from erosion, have been developed by NAES for farmers.

As technologies developed in cereals and legumes are gradually extended to farmers, attention must now be directed to root crops also. A major bottle-neck in its production is the rapid deterioration of its planting material. The NAES must endeavour to adapt the minisett technique of producing yam setts to the savanna environment.

Cassava, a drought tolerant root crop, is gaining importance in the region. Nyankpala has to select and recommend suitable varieties for inclusion in the farming systems of the zone.

Cotton production which declined in the 1970s is on the upswing again. There is now a lot of interest in this crop even among the donor community. To support increasing productivity in this crop, particular attention has to be paid to insect control tactics that are productive and economic and yet environmentally friendly. Efforts should be directed at devising means of forecasting insect out-breaks not only in cotton but also in other crops. That way, expenditure on insecticidal control can be minimized.

The NAES concerns itself with technologies that support food production. This is as it should be. However, recent trends in surplus production of cereals make it necessary that initiatives are taken towards investigating processing methods for some of the crops on which research is currently conducted at NAES. Information now available shows that there are some high yielding varieties of sorghum, which are not so preferred for human consumption as a flour, but which are excellent for brewing beer. It is the desire of my Ministry that NAES selects even better varieties and links up with the beer breweries and others in this endeavour in order to bring to the market place, as soon as possible, a beer brewed from locally grown sorghum.

Today, most of the straw from crop production practices are lost through burning. I sometimes wonder what the impact on our animal population and consequently our diets and also our leather industries would be if the straw could be processed in a way as to enhance its feeding value for animals.

Ladies and Gentlemen,

Ghana's main means of carrying produce about is in jute sacks. This is true when we carry produce to our villages on our heads, or on bicycles or on trucks. It is also so when we carry our precious agricultural products abroad to earn foreign exchange. Therefore millions of these sacks are used every year. Almost all these sacks are made from imported jute. I am informed that Urena lobata and Kenaf from which sacks can be made grow very well in the savannas. In the past, attempts at encouraging farmers to produce the crops in sole plantings failed. It is necessary now to investigate how to combine food crop production with bast fibre production so as to make the proposition attractive to farmers. Attempts at growing bast fibre as stakes for weak-stemmed crops may also contribute to its attractiveness.

I wish to congratulate the station for its pioneering efforts in adapting soya bean to the savanna environment in Ghana. However the station's focus on the use of the crop at the home-level only may have to be reviewed to incorporate the application of the crop to the many uses known. The extraction of oil, the manufacture of feed, the manufacture of milk, meat analogues and baby foods are all areas which should be considered in the development of varieties.

The extension of Akosombo power and consequent availability of both energy and water in the region opens up opportunities for industrialization which never existed in the past. We call on our scientists to initiate long term plans which take into account the future impact of the availability of power and water on their work. We wish to see our industrialists forge close links with our scientists to examine the opportunities that have been created especially in the agro-processing sector to add value to what is produced on the farm.

I am aware that the subjects which I have indicated require research attention when added to those already being pursued by the station make a long, complex and expensive research agenda which may overwhelm the resources of NAES. This is where our power of discrimination and discernment is most needed. The choices we make must be based on need, the potential for success and the station's capability to deliver.

Ladies and Gentlemen,

Since the need may be greater than our ability to accomplish, it becomes necessary to work with collaborators and donors with whose support more can be achieved. In this regard this station has been most fortunate in possessing an important and reliable donor in the Federal Republic of Germany. I wish on behalf of the people and Government of Ghana to extend to the people and Government of the Federal Republic of Germany our deepest appreciation for the past,

present and much expected increased future support and good will. We hope the success of our cooperation will further strengthen the bonds of friendship existing between our two peoples.

Ladies and Gentlemen,

I am also closely watching the developments that are currently underway with the view to securing assistance from the French Government for rice research and development in northern Ghana. I am anxious that the agreement now under consideration can be signed without any delay so that Ghana can benefit from the wide experience that Institut de Recherche Agronomiques Tropicales et des Cultures Vivrieres (IRAT) of France has gained through working for a long time in neighbouring francophone countries.

May I take this opportunity to express my thanks to the French Government for the many forms of assistance that it is now offering to our country.

I wish all of you fruitful deliberations.

Thank you.

Keynote address by Commodore Steve Obimpeh (Rtd), The PNDC Secretary of Agriculture, Read on his behalf by Mr. Ibrahim Adam, The PNDC Deputy Secretary for Agriculture, At the Opening Session of the 2nd National Workshop On Improving Farming Systems in the Savanna Zone of Ghana, 24th April, 1990.

Honourable PNDC Secretaries,

Distinguished guests,

Participants ,

Ladies and Gentlemen.

I am happy to have the opportunity to be with you at this workshop during which agriculture in the savanna zone will be the focus of discussion.

The interior savanna constitutes 51% of Ghana's land area. In this zone are grown most of our sorghum, millet, rice, groundnuts, cowpeas, yam and cotton. Considering the vast expanse of the savanna, the opportunities for turning the area into a grain basket of the country are very great indeed. However, the achievement of this goal will come about when certain constraints have been overcome. It is for the provision of information on how to surmount these constraints that Nyankpala was established and hence our meeting here this morning.

The purpose of this workshop is to discuss problems that hinder agricultural productivity and indicate action plans and research priorities for a rapid and sustainable improvement of farming systems in the zone. The discussions should also point to available technologies for alleviating low productivity and their extension, and also lead to better acquaintance of participants and hence better co-ordination of efforts.

The Nyankpala Agricultural Experiment Station located in the drought-prone, distant north and surrounded by farming communities that are more economically disadvantaged has made the development of sustainable technologies a major goal. Its focus is on the improvement of the farming system as a whole. The early agricultural researchers in the tropical world concentrated on developing improved high yielding varieties which when combined with fertilizers and agrochemicals and sometimes irrigation gave excellent yields. While great successes were scored with the better endowed farmers a large proportion of peasant farmers were left untouched since the research did not take into account the resource and other constraints of such farmers who constituted the clientele of the research. To overcome this problem agricultural research must be conducted with a farming systems perspective.

Farming systems research views the farm in a holistic manner and considers interactions in the system. Its major objective is to increase the productivity of the farming systems by generating appropriate new technologies. It includes an understanding and evaluation of the physical and socio-economic environment of existing farming systems and the examination of the skills, constraints, preferences and aspirations of farmers and thus facilitates the capacity of research organizations to conduct research on farmers' genuine concerns. It incorporates on-farm research which has the objective of developing location specific improved technologies for target groups of farmers and experiment station research which has a broader perspective of overcoming major limitations in farming systems. The location specificity of on-farm research should promote the interaction of research and extension. And this interaction has to be kept under constant review with the objective of improving it.

I am aware of the excellent research work that the NAES has done over the years. However, the area that I wish NAES to strengthen is their relationship with client organizations. I would like to recommend that NAES builds formal linkages that ensures a permanent dialogue with consumers of research information in the Ministry of Agriculture, other government agencies, non-governmental organizations and farming communities to facilitate effective planning of research programmes, setting of priorities, implementation of programmes and extension of results of research.

I am particularly anxious that these strong links are built in this zone since in the wake of the economic recovery programme and the assistance being offered by multilateral agencies as well as bilateral donors, the agenda of activities in the zone, for the years ahead, are going to be particularly extensive. Among the donor assisted projects which have been launched and with which there has to be a strong interaction for input of improved technologies and training are;

1. International Fund for Agricultural Development (IFAD) supported Smallholder Rehabilitation and Development Programme and its related research component on yams, cassava and sweet potatoes.

2. International Development Agency (IDA) supported Pilot Extension Project which seeks to demonstrate the feasibility and effectiveness of the Training and Visit System of extension in certain regions including the three regions in the Interior Savanna Zone.

3. IDA supported research programme under which the Crops Research Institute including Nyankpala will formulate satisfactory technical packages to support the resuscitation of (a) economic cotton production (b) efficient utilization of wet lowlands or valley bottoms in the production of swamp rice and other crops and (c) development of water management techniques directed at raising irrigated crop yields and production efficiency.

Other projects which are under consideration and to which Nyankpala will be expected to make a contribution are the IDA assisted Pilot Small Scale Irrigation Project, the Rehabilitation of Small Reservoirs and Ponds for livestock, domestic water and irrigation in the Northern and Upper Regions and the Rural Action Programme in Damongo and Bimbilla supported by the Federal Republic of Germany.

Ladies and Gentlemen

The need to protect the environment especially as we increase food production has become a topical issue in the last two decades. This is so because of the often total neglect and destruction of the environment as we pursue the goal of adequate food production. The truth is that we cannot continue to produce food if we do not protect the environment. If we do not develop sustainable systems of food production we cannot maintain the environment.

The savanna environment is very fragile. During half of the year rainfall is sparse and unpredictable but during the other half there is complete drought. Tree and grass cover is much less and the soils are shallow and infertile. Indiscriminate bush burning has almost become a tradition. Ironically, population rates of increase in the zone are much higher. Farmers are therefore constantly searching for more land to farm on. The need to conserve the environment in the savanna zone now is urgent if we are not to jeopardise our long term production through practices that bring only short term advantages. I am therefore gratified that preservation of the environment under increased agricultural production is the topic for a panel discussion during the workshop. I am looking forward to some definitive recommendations from this discussion for consideration in our planning in the Ministry of Agriculture.

May I finally take this opportunity to wish the participants fruitful deliberations.

Thank you.

SESSION 1

Chairman: Mr. E.A. Addison, Director, Crops Research Institute, Kumasi

A SYNOPSIS ON THE CLIMATE OF THE NORTH OF GHANA

C.N. Kasei

(Soil Research Institute/Nyankpala Agric Expt. Station)

Abstract

This report reviews the weather, that is, the recent climatic changes especially rainfall, towards a harsher trend in the North of Ghana comprising the Sudano-Guinea Savanna Zone. No suggestions have been offered in this paper for its improvement because this situation is not unique to the Savanna Zone of Ghana. The zone has a land area of 60,960 square kilometres between latitudes 8° and 11° North with a greater portion being semi-arid. Nyankpala-Tamale in the Guinea Zone and Navrongo in the Sudan Zone for which climatic data are available have been selected for assessing the weather conditions of the area. Annual rainfall is about 1,000 mm with a monomodal pattern. Precipitation has been highly variable from year to year for nearly 30 years, the variability being 15-20 percent in the Guinea Savanna and 20-30 percent in the Sudan Savanna zones, respectively. The moisture situation in the area shows more drier years from 1977. In the Guinea Savanna zone, 70 percent of the annual averages underestimated the long-term mean in a decade (1977-86). Similarly, in the Sudan Zone, the multiannual mean rainfall had declined from 1,095 mm in 1962 to 992 mm by 1989. In the four humid months from June to September, only 20% moisture surplus occurs and potential evapotranspiration exceeds precipitation for the rest of the year. Temperature variation from year to year are small and generally the seasonal variation is below 10°C. Changes in the seasons correspond to the wind pattern with a dry north-easterly wind during the harmattan and a wet south-westerly wind during the monsoons. Solar radiation is relatively abundant throughout the year over the area except for cloud cover during the monsoon rains.

Introduction

The North of Ghana lies between latitudes 8° and 11°N with a land area of 60,960 square kilometres, most of which is semi-arid (Fig.1). It comprises the Sudan and Guinea Savanna Zones with annual precipitation of between 900 - 1000 mm. The climatic classification of the area is described by Papadakis (1966) as semi-arid tropical and by Kowal and Kassam (1978) as mild sub-arid wooded savanna.

Climate probably sets the broad limits to the existence of man and his crops in a given area. The climate of the North of Ghana includes the aerial environment which comprises solar radiation, temperature, rainfall, cloud and wind. These climatic variables are of paramount importance to man and plants in

Map of Semiarid Ghana

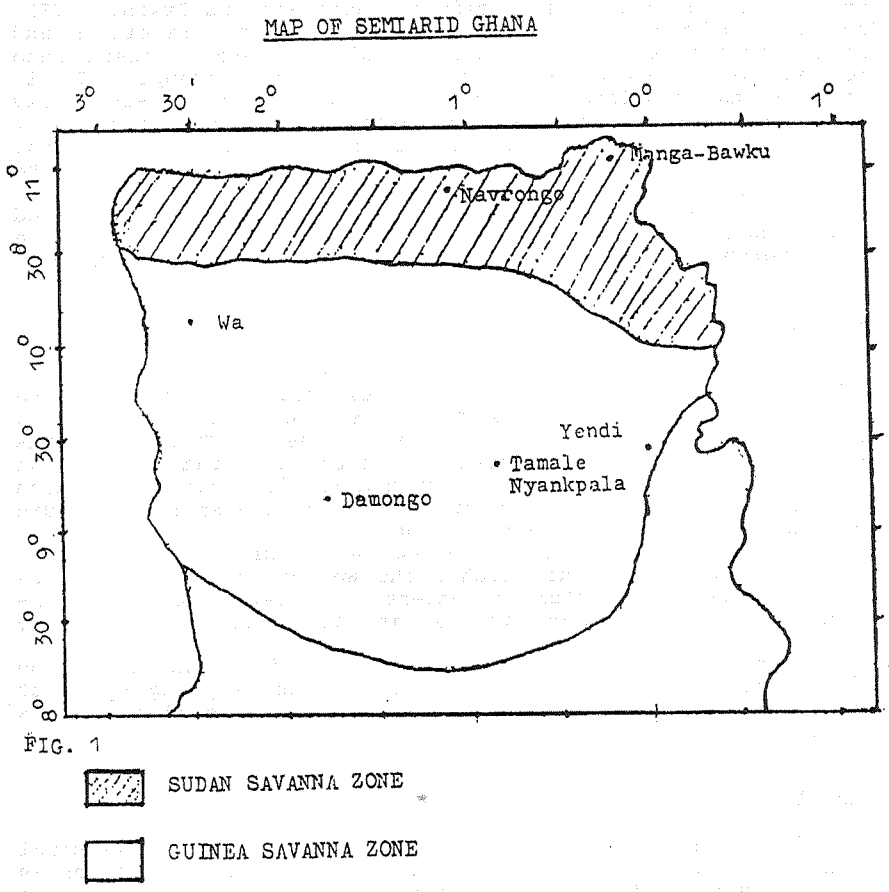


FIG. 1

particular. Increased demand for food and shelter either due to population explosion in the area or other natural hazards have invariably led to increased encroachment on the natural vegetation. The risk is that the natural vegetation under all ecological zones are usually in a delicate equilibrium with the climate (Gomez-Pompa et al, 1972) and its indiscriminate removal brings about serious disturbances of the environment and generally leads to a harsher climate (Goodland and Irwin, 1975). The equilibrium tends to be fragile in areas of transition and the realization of the encroachment of the Sahara desert into the semi-arid area of West Africa is a good example. It is possible that significant climatic changes do occur especially in the West African savanna (Jenkinson, 1973, Winstanley, 1973) and in many ecological zones but are not immediately realized. However, it is possible to improve the delicate balance and the climax vegetation that has been removed.

These observations and the continued pressure for increased food production have necessitated the assessment of the climate of the North of Ghana for more effective agricultural planning.

General

In broad terms the climate of the North of Ghana is closely linked with the prevailing general circulation affecting the West African subregion. Two air masses of very contrasting characteristics determine the climate there. These are the harmattan winds generally called the North East Trade Winds that usher in the dry season and the South Atlantic Maritime Air Mass referred to as the south west monsoon which transports moisture into the area during the rainy season.

The convergence zone of the two air masses is the inter-tropical convergence zone (ITCZ). The weather at a given place in the region is therefore dependent to a large extent on the position of this discontinuity in time relative to the particular location.

Longterm temperature variation is very little and it is the moisture that imposes its seasonality on the cropping cycle of the area. Also evapotranspiration is the variable that assumes dominance in the moisture balance of the zone.

Rainfall

The moisture laden monsoon winds whose seasonal characteristics have been reported by Adejokun (1966) influences the flow pattern of the weather and cloud distribution over the area. An assessment of the moisture situation at Nyankpala-Tamale in the Guinea Savanna Zone and Navrongo in the Sudan Savanna Zone (Fig. 1) based on long term records (1936-1989) obtained for the two representative locations indicates a

TABLE 1. SUMMARY OF SOME IMPORTANT CLIMATIC DATA

Annual Mean Values	Navrongo		Nyankpala-Tamale	
	1936-62	1963-89	1936-62	1963-89
Potential evapotranspiration (mm)	1703.0	1899.1	1540.0	1775.8
Temperature* (^{o}C)	28.3	28.8	27.8	28.3
Solar radiation (cal/cm^{2})	475	500	450	490
Wind (knots)	4.0	5.1	4.0	4.8

* Temperature data for 1956-89 was available.

gradual change towards a harsher climate sometime during the nineteen sixties (Table 1).

It is observed in the years under consideration that similar variables of climatic gradients exist but the two locations are differentiated particularly by a seasonal amount (Table 2) and distribution of rainfall (Fig. 2 and 3). The movement of the pseudo-frontal zone or the intertropical convergence zone to be precise, is in close association with the rainfall in the region (Flohn, 1960).

TABLE 2. SUMMARY OF SOME IMPORTANT CLIMATIC DATA

Annual Mean Values	Navrongo		Nyankpala-Tamale	
	1936-62	1963-89	1936-65	1966-89
Rainfall (mm)	1095.0	992.0	1110.5	1043.0
Rain days	77	67	92	75
Rainfall wet season*	1000.0	744.0	1000.0	679.1
Rain days " "	69	48	78	44
Coeff. of variations (%)	20	20-30	15	15-20

* From June to September.

In the North of Ghana with a monomodal rainfall, both the onset and cessation of the rains are irregular; and the temporal and spatial variabilities in precipitation are well marked. The mean annual rainfall is between 900-1000 mm and about 90 percent of the rains are realised during the four humid months from June to September (Fig. 2 and 3) when the monsoon shows its full effect in the area. Precipitation has been highly variable from year to year for over 20 years. The variability being 15-20 percent in the Guinea Savanna and 20-30 percent in the Sudan Savanna zones. The moisture situation showed more drier years in the two locations from 1977. Only five wet years were recorded for each location between 1977-89, and within this period 70 percent of

Fig. 2 and 3:

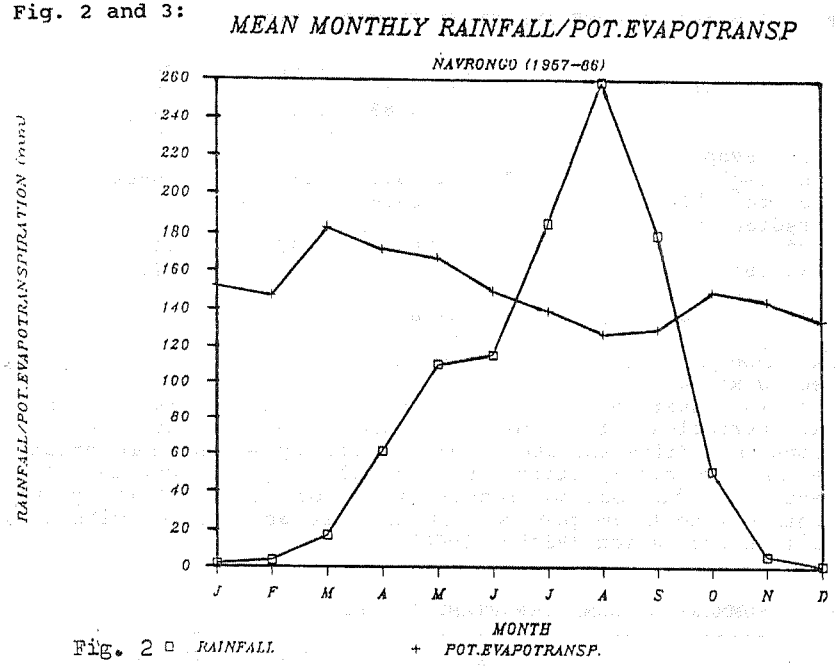


Fig. 2 □ RAINFALL + POT.EVAPOTRANSP.

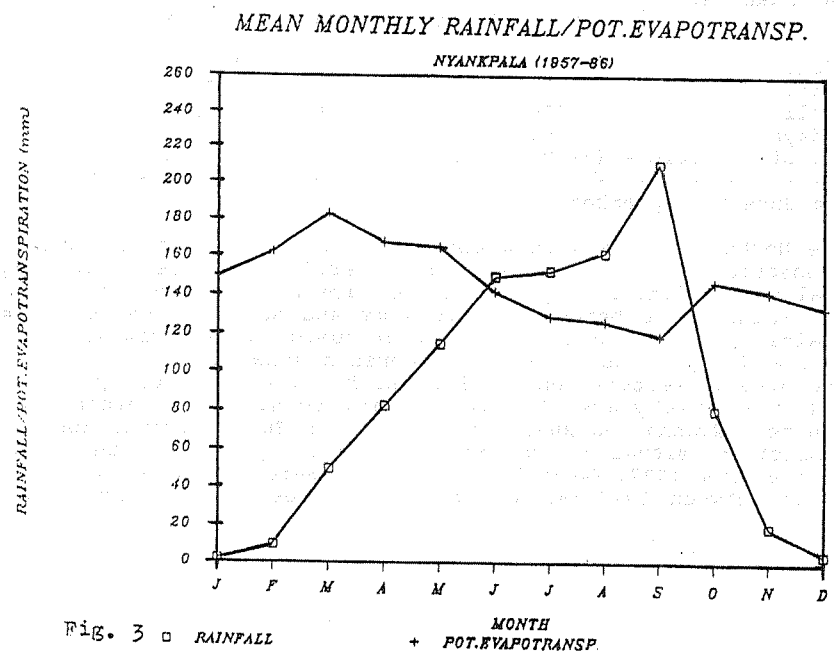


Fig. 3 □ RAINFALL + POT.EVAPOTRANSP.

the annual averages underestimated the long term mean in a decade (1977-86). The multiannual mean rainfall also suggests a comparatively adverse moisture situation (Table 2).

Potential evapotranspiration (PE)

An idea of the water balance of the two representative locations is presented graphically in figures 2 and 3 using the Penman (1948) method for the computation of PE. This method has been found reliable over a wide range of climatic conditions. The peak periods are in March and October with values of over 7 mm and 5 mm/day. Differences in PE values for the periods (Table 1) probably caused by changes in the surface water balance may affect the climate and may in turn have important consequences for the sustainability of agricultural production and natural vegetation systems. There has also been an increased probability of climatic changes in the area due to the introduction of mechanized agriculture in the 1970's ushering in an indiscriminate removal of vegetation which carried with it subsequent changes in the associated soil and air environment.

Temperature

Assessing temperature regimes dominating the North of Ghana was based on long-term data obtained for Navrongo in the Sudan Savanna Zone and Nyankpala in the Guinea Savanna Zone. The values are mean annual values (Table 1) which have a tendency to smooth out daily variations but this is considered to have little consequence in assessing thermal regimes. The consistently high mean annual temperature (Table 1) gives the area a warm environment. Temperature differences during the period under comparison are relatively small being 0.5^{o}C higher for both the Sudan and Guinea Savanna Zones (Table 1). However, temperatures do vary significantly within the seasons.

Solar Radiation

The annual temperature increase between the two periods for the Sudan and Guinea Savanna Zones corresponds with the increase in solar radiation and decrease in annual rainfall (Table 1). This affects agricultural production in the zone. Radiation values for the periods being compared show a higher trend in both locations. Generally, relatively uniform and high radiation levels exists throughout the year in the area.

Wind

Changes in the seasons correspond to the wind pattern in the area. There is a dry easterly wind normally described as the 'Harmattan' and the wet south-westerly monsoon wind which normally ushers in the rainy season. Wind records for Nyankpala-Tamale show that the harmattan blows from a prevailing north-easterly direction while the monsoon blows from the south-west. Wind records for Navrongo show the harmattan to be even more pronounced from the North-east with the monsoon having stronger south-westerly component. The general trend in the wind has assumed an increasing effect over the area (Table 1).

Conclusion

The distribution of rainfall in the North of Ghana is dependent on the seasonal northward movement of the inter tropical convergence zone both in time and space.

The indiscriminate removal of the natural vegetation which is in a delicate equilibrium with the climate must have led to a harsher climate in the area. Increases in the values of the weather variables could possibly be that the area is in the initial stages of undergoing a gradual climatic change.

It is pertinent to mention that these observations are preliminary and further studies should give ground for more definite conclusions.

References

Adejokun, J.A. 1966. A three dimensional study of the ITD Tech. Note No. 30 Met Dept. Lagos Nigeria.

Flohn H. 1960. The Structure of the Intertropical Convergence Zone. Pages 244-264 in D.J. Bargman, ed. Tropical meteorology in Africa, Munitalp Foundation, Nairobi.

Goodland, R.J.A. and H.S. Irwin. 1975. Amazon Jungle. Green Hell to Red Desert? Reprinted from Landscape Planning Vol. 1, No. 2/3: 123-254.

Gomez-Pompa, A.; C. Vazques-Yannes, and S.Guevara. 1972. The Tropical Rain Forest: A Non-renewable Resource. Science 117: 762-765.

Jenkinson, A.F. 1973. A note on variations in May to September rainfall in West African marginal rainfall areas. Drought in Africa (eds. D. Dalby and R.J. Harrison Church) pp. 31-32. Centre for African studies. univ. of London.

Kowal, J.M. and A.H. Kassam. 1978. Agricultural Ecology of savanna - A study of West Africa. (ed. Kowal J.M. and Kassam A.H.) 3: 71-72.

Papadakis, J. 1966. Crop ecology survey in West Africa. FAO 1966 vol. 1, 3: 10-17.

Penman, H.L. 1948. Natural evaporation from open water, bare soil and grass, Proc. Royal Soc. A. vol. 193 pp 120-145.

Winstanley A.F. 1973. Rainfall pattern and general atmospheric circulation. Nature (London) 245, pp 190-194.

Discussion

J. A. KWARTENG

Is the increase in potential evapotranspiration and the decrease in rainfall observed between 1966-89 an increasing and decreasing trend respectively or an average effect?

C. N. KASEI

It is an observed annual increasing trend although there are wet years that break this trend but on the long-term basis the evapotranspiration been greater than the 1936-65 values.

K. A. HAIZEL

Why do we attribute the drying conditions prevailing to the removal of vegetation?

C. N. KASEI

Hydrological balance explains that vegetation induces rainfall.

J.A. ADOGOBA

What is the connection between erosion, transpiration and excess water?

C. N. KASEI

During the period of excess water or water supplies there is a high probability of erosion on the light soils of the savanna but then evapotranspiration is low.

CROPPING PRACTICES IN SEMI-ARID GHANA: A COMPARISON OF SOME RESEARCH AND TRADITIONAL METHODS.

L. O. Tetebo

(Nyankpala Agricultural Experiment Station)

Introduction

The role of trees in improved agroforestry systems in alleviating the numerous agricultural constraints (such as erosion, low soil fertility etc.) and improving food production is being recognized by various governments and farmers in Africa today.

A careful study of the problems and limitations of the present traditional systems show that there is the need for an improved integrated system that would effectively utilize all available resources for improved food production.

The development of technologies for increasing food production through the increase in land productivity thus presents a challenge to scientists. This will involve developing, not only for the humid areas but also for the subhumid areas, high and sustainable productive farming techniques that are ecologically sound, economically viable and culturally acceptable.

The major constraint to crop production in Northern Ghana, is the inherent low fertility of the soils. This has been brought about by:

* continuous cropping without proper management of the soils,
* rampant bush fires,
* burning of crop and fallow residues,
* erosion and
* little or non-use of chemical fertilizers by the subsistence farmers - for economic reasons.

Areas with very low population densities still practice shifting cultivation. The important role of the fallow period for soil rejuvenation in traditional shifting cultivation is well known (Nye and Greenland, 1960). Where land is abundant, long fallow periods facilitate the restoration of soil productivity, resulting in low productivity over time, but biologically stable production systems. The approach for maintaining the desired physical soil conditions is appropriate management of surface soil through the use of residue and mulch. Loss of nutrients during cropping can be compensated for by the judicious use of chemical inputs (Kang and Juo, 1983) but maintenance of adequate levels of soil organic matter and judicious crop residue management play important roles in sustainable crop production (Ofori, 1973; Kang and Juo, 1983).

An integrated soil fertility management system, combining the use of chemical soil amendments and biological

and organic nutrient sources, will therefore be the most desirable nutrient-management system for these soils. This paper discusses the possible use of pigeon peas (Cajanus cajan) in soil improvement systems to enhance the overall productivity.

Materials and methods

A trial was started in Nakpa in the Bimbilla district in 1987. The land had been left fallow for fifteen (15) years. Ten farmers were selected to participate in this researcher-managed trial - where they provided the labour and judged the outcome.

A two-factor randomised complete block design with five replications was established. Plot size was 13 m * 6 m, on ridges, 1.1 m apart.

Factor 1. Cropping patterns at 3 levels

a. Farmers' practice (FP) - groundnuts (Arachis hypogaea) were planted on the ridge, maize (Zea mays) by the side of the ridge and sorghum (Sorghum bicolor) broadcast in the furrows.

b. Strip rotation (SR) - four central ridges each of maize and groundnuts. Two border ridges each of the same crops. Two rows of groundnuts per ridge. Sorghum was broadcast in the maize furrows and later thinned to the required densities.

c. Alley Cropping (AC) - just as strip rotation with the third, seventh, and eleventh ridges planted to pigeon pea.

FACTOR 2. CROP DENSITIES AT 2 LEVELS. (PLANT/HA).

Crop	Variety	High density	Low density
Maize	Dobidi	30303	22727
Groundnut	F-mix	90909	45455
Sorghum	Local 29	45454	30681
Pigeon pea	Wantugu pink	6818	6818

In 1987 a basal application of 30 kg N/ha was applied to the maize in all plots and two weeks later top-dressed with 30 kg N/ha. In 1988, however, only 30 kg N/ha basal application was given to the maize.

In 1987, the first year of the pigeon pea, no pruning was done. The crop was pruned twice the following year and was used as mulch/manure in the alley cropped plots. The first pruning took place two weeks before planting the groundnuts and the maize and the second took place a month later. Sorghum was planted two weeks after germination of the maize.

Observation

Rainfall at the experimental site for 1988 was 1184.2 mm. This was 16.8% more than that of 1987 but the distribution was about the same. Groundnut germination was better in the second year. Mild streak attack was, however, observed on the maize.

Results and discussion

The results of 1988, (Table 1), generally, showed significant yield increases over that of the year 1987 and differences due to the cropping patterns were also observed. Rotational effects on the crops in the different cropping practices showed in the first year of rotation, 1988.

TABLE 1. GRAIN YIELD OF MAIZE, GROUNDNUT AND SORGHUM KG/HA, 1987/88, NAKPA

Cropping pattern	Density	maize 87	maize 88	%Y 88/87	Sorghum 87	Sorghum 88	%Y 88/87	G'nut 87	G'nut 88
FP	H	1375	1871	36	918	746	-19	86	939
	L	1292	1909	48	1218	1121	-8	136	901
SR	H	1186	3166	166	335	898	168	262	1701
	L	1386	3242	133	389	1159	190	261	1879
AC	H	967	3587	271	185	1061	474	257	1950
	L	797	2859	259	217	1132	422	250	2172
Mean		1167	2273		544	1019		208	1590
LSD (05)		391	791		236	377		100	477
C.V. %		25	31		33	40		37	32

87 - 1987; 88 - 1988;
%Y - percentage yield increase of 1988 over 1987.
FP - farmer's practice; L - low density; H - high density.
SR - strip rotation; AC - alley cropping; G'nut - groundnut.

Maize yields (Table 1, Fig. 1) in the first year of study, 1987, did not differ between the cropping systems. In the second year of study, however, the yields were significantly higher in the strip rotation and alley cropping plots (about 3000 kg/ha) than in the farmer's practice (less than 2000 kg/ha). Yield increases in maize in the second year over that of the previous year varied between 36% in the farmer's practice to 271% in the alley cropping fields.

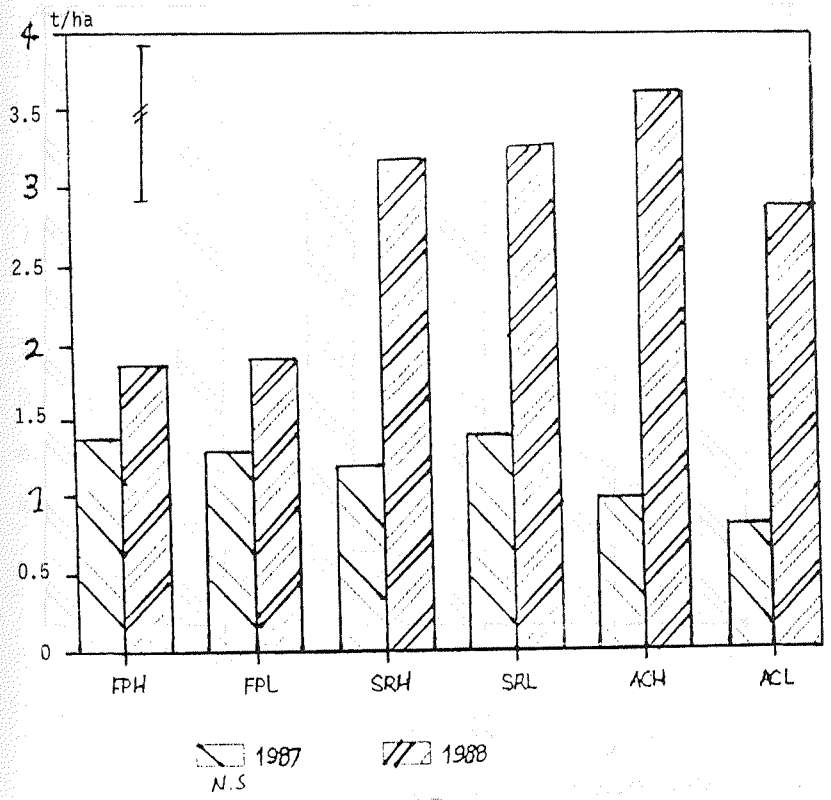


Fig 1: Maize Yield for 1987 and 1988.

Sorghum yield in 1987, (Table 1, Fig. 2) were significantly higher in the farmer's practice, about 1000 kg/ha, than in the other cropping practices which had yields less than 400 kg/ha. Though there were no significant difference in yield in 1988, the yield of the FP was depressed slightly by 19 and 8 % in the high and low plant densities, respectively. The yields in SR and AC plots increased tremendously, by 168 and 474% respectively over that of 1987.

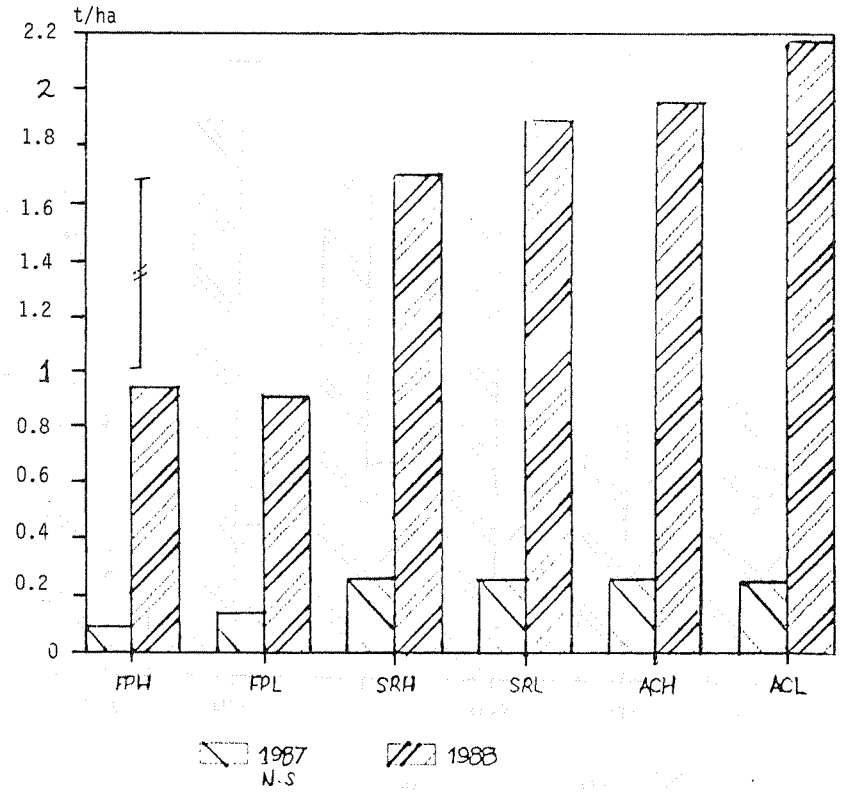


Fig 3: G'nut Yield for 1987 and 1988.

Yield increases in the cereals were mainly due to the residual nitrogen obtained in the cereal-legume rotation and the additional mulch/manure of the pigeon pea prunings in the AC which helped improve the soil fertility in the respective plots over that of the FP plots. Though sorghum yields were increased in the SR and AC plots, all plots with higher densities had lesser yields than their corresponding low densities. Differences between the low and high densities of AC, SR and FP were 71, 261 and 375 kg/ha respectively.

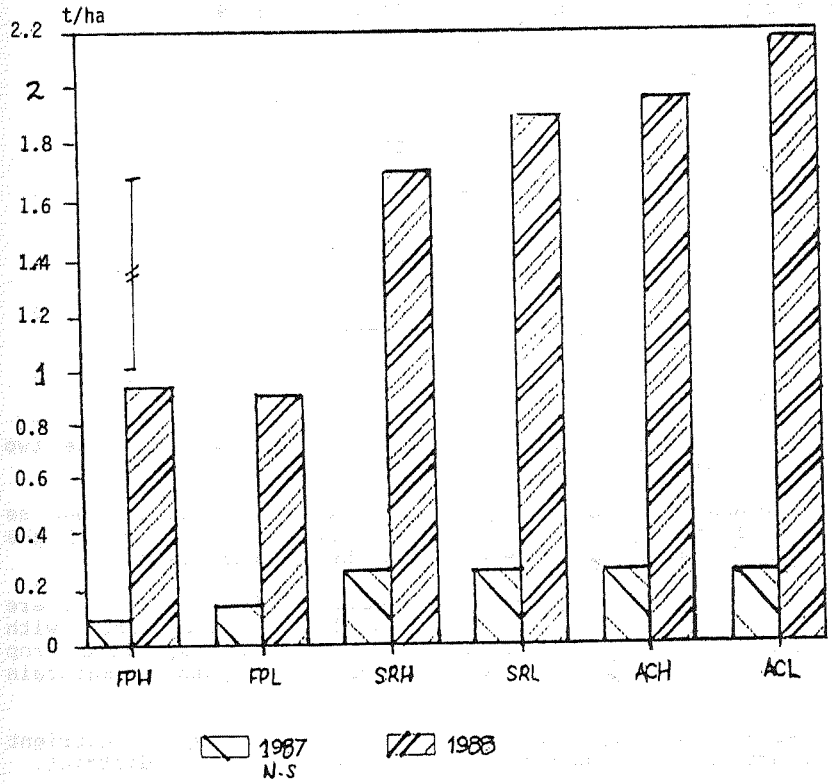


Fig 3: G'nut Yield for 1987 and 1988.

In 1987, groundnut yields (Table 1, Fig. 3) were generally low due to poor germination. In 1988, the SR and AC plots showed remarkable differences over the FP plots. Pigeon pea yield increased sharply in 1988. This could be attributed to the effect of pruning on the crop. Pruning the crop caused profused branching thereby increasing the number of flowers/pods formed on each branch.

Energy yields of 1987 (Table 2) were not significantly different from each other. In 1988, the large increases were due partly to the favourable weather but mainly to the effects of the different cropping practices which varied from 62900 MJ/ha in the FP to 118800 MJ/ha in AC.

TABLE 2. ENERGY YIELD FOR 1987 AND 1988. ('000 MJ)

Cropping pattern	Density	1987	1988
Farmer's practice	H	36.7	62.9
	L	41.2	68.2
Strip rotation	H	29.5	103.8
	L	33.3	113.3
Alley cropping	H	23.8	118.8
	L	21.5	114.4
Mean		31	97
LSD (05)		n.s	21
C.V. %		28	21

Conclusion

The tentative conclusions that can be drawn from the two years work are:

1. Sorghum does well on poor soils at low densities but as the fertility improves, the spatial distribution of the crop is important in determining the optimum yield.

2. An integrated soil fertility management is necessary. There is the need to combine chemical soil amendments with biological (organic) nutrient source and compatible crop combinations at a reduced cost of farm inputs to maintain high yields.

3. Alley cropping with pigeon pea is one biological nutrient source with a high potential for the Bimbilla district.

References

Kang, B.T. and A.S.R. Juo, 1983. Management of low fertility soils in tropical Africa for food crop production. In F.H. Benroth, H. Neel and H. Eswaran (eds),Proceedings of the Fourth International Soil Classification Workshop (Kigali, Rwanda). Brussels: ABOS-AGCD.

Nye, P.H. and H. Greeland, 1960. Soils under shifting cultivation. Technical Communication 51 Commonwealth Bureau of Soils, Farnham England.

Ofori, C.S. 1973. Decline in fertility status of a tropical forest Ochrosol under continuous cropping. Experimental Agric. 9: 15-22.

Discussion

QUASHIE-SAM

Was the 15 year fallow plot subjected to the usual hazards of burning?

L. TETEBO

As far as the land history shows it was left to grass fallow.

D.M. OSAFO

Number of replications used in the experiment comparing farmers practices and research managed practices?

L. TETEBO

Five replications were used in the experiment. All the replications were on a contiguous piece of land that has been left fallow for 15 years. Variation among the treatments was about 21%. For on-farm experiment this shows a high precision.

K.A. HAIZEL

What statistical design was used?

L. TETEBO

A randomised complete block design with six treatments was used.

H.K. DAPAAH

In the first year you used 60 kg N/ha, however, in the second year you reduced it to 30 kg N/ha. What reasons do you have for this reduction?

L. TETEBO

Consideration was given to low input sustainable agriculture. The on-farm team is thinking of low cost inputs for our resource poor farmers in a stable ecology.

J. GYESEY

Is it only appropriate to use randomised complete block design for maize when working with few farmers or you can use Latin square design or any other design?

L. TETEBO

A Latin square design has a limitation where the number of replications must equal the number of treatments and the randomization is both vertical and horizontal. In this case with 6 treatments and working with ten farmers management of the trials by the farmers would have been a problem. Rather each complete block is managed by two of the ten farmers.

A. RUNGE-METZGER

Did you carry out the same trial in 1989? If yes, what were the results?

L. TETEBO

Yes. The trend appears quite similar but (at that time) the results were being analysed.

TOWARDS THE INSTITUTIONALISATION OF ON-FARM EXPERIMENTATION IN NORTHERN GHANA

Tommaso del Giudice

(Nyankpala Agricultural Experiment Station)

Introduction

The NAES On-Farm Research Programme started in 1982 with diagnostic work including On-Farm Surveys and one year later, in 1983, with On-Farm Experimentation (OFE). At this early stage, OFE was done with a few farmers on a few representative areas of the Northern Region of Ghana. From 1984 onwards, the experimental work was extended to the Upper East Region. In the Upper West Region, OFE was started last year.

In the past the on-farm trials were planned by NAES research staff and implemented with farmers under the close supervision of NAES enumerators, who were closely monitored by researchers. But, the rising needs of generating new technologies related to increased problems in agriculture made it necessary to achieve a broader coverage of research in the whole mandate area, according to the existing farming systems.

For this reason, NAES On-Farm Research made use of the on-farm research infrastructure existing in the mandate area. This includes field agents and field personnel from Crop Services and Extension Departments of the Ministry of Agriculture as well as the Association of Church Development Projects (ACDEP) and Ghana Grains Development Project (GGDP).

With the field agents from the Extension and Crop Services Departments of the Ministry of Agriculture, two forms of collaboration were experienced in the supervision of on-farm trials:

- **First**, the field agents supervised on-farm experiments in addition to their regular duties, and
- **second**, they were formally seconded to the NAES on- farm research programme to perform certain tasks.

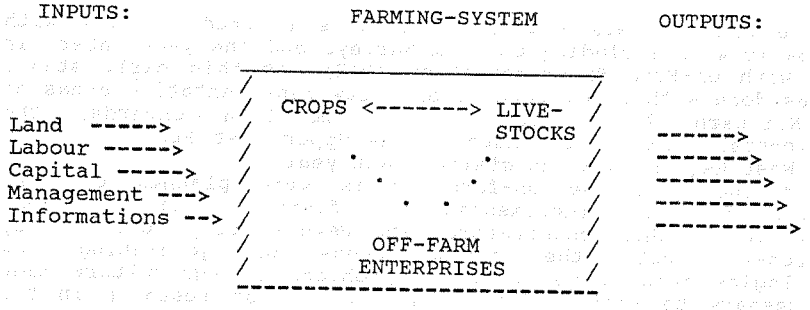
Within this two forms of collaboration big differences in the efficiency of the research work were observed. The field agents who did the supervision of on-farm experiments in addition to their regular duties provided less accurate data during the whole experimental process.

The Farming Systems (FS) approach

The precondition for generating new agricultural technologies that fit into the existing farming systems and help

farmers to overcome production constraints without creating new ones is the accurate differentiation of farming systems within the mandate area. Therefore, it is necessary to consider the three components of farming systems: crops, livestock and off-farm enterprise (Gilbert, Normann and Winch, 1980) (Fig. 1) .

FIGURE 1: RELATIONSHIPS BETWEEN THE COMPONENTS OF A FARMING SYSTEM, INPUT AND OUTPUT FLOW



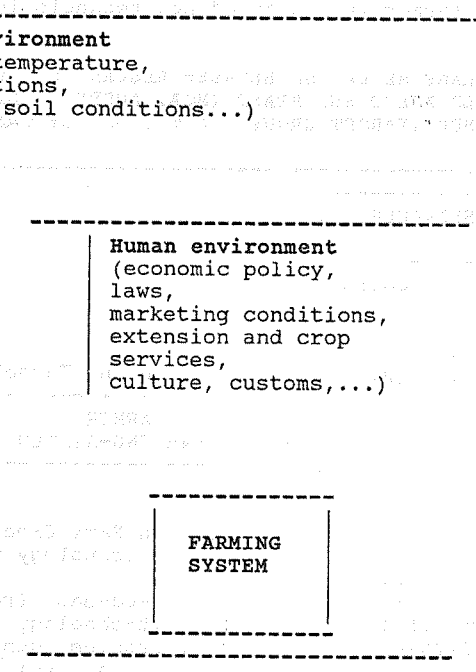
A "farming system" is the result of interaction of several independent components, mainly **crops**, **livestock**, and **off-farm enterprise**. At the centre of the interaction are the farmers themselves whose household and means of livelihood are intimately linked with those components.
In a specific farming system, families allocate certain quantities and qualities of basic inputs (land, labour, capital, management and information) to the three components of the system (crops, livestock, and off-farm enterprise), in such a manner that with its knowledge the family progresses to achieve their goal(s) (Fig. 1).

All the elements of the farming system are closely related to their particular environment which is of two kinds: material and human (Fig. 2).

The human environment consists of economic (economic policy), institutional (public laws; credit and marketing conditions; extension services; researchers; NGOs; property right for land), and social elements (culture and customs within a community).

These elements determine quantities as well as absolute and relative prices of inputs and influence the availability of physical infrastructure, credit facilities and marketing conditions.
They strongly influence the access which the community members have to inputs.

FIGURE 2: RELATIONSHIPS BETWEEN THE FARMING SYSTEMS AND THE HUMAN AND MATERIAL ENVIRONMENT



They determine the land and labour distribution by age and gender between and within the households.

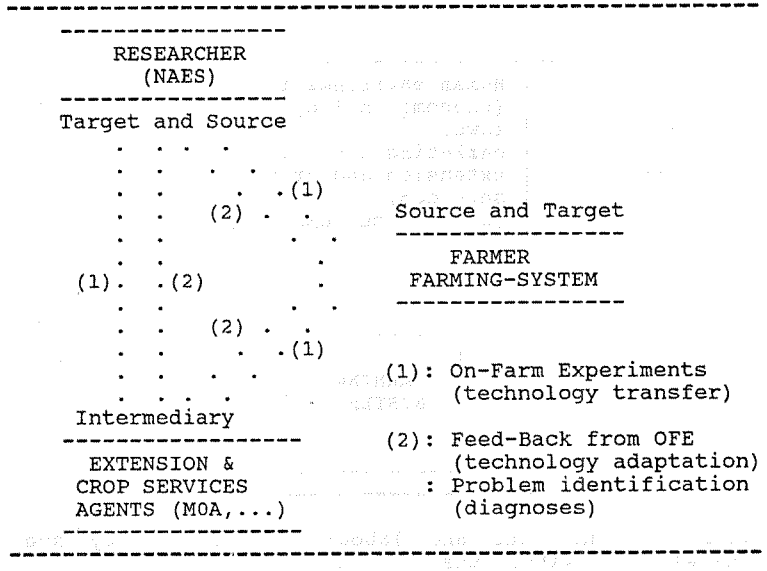
A suitable human environment is given by the **material environment** which consists of physical and biological elements.
The physical elements include rainfall, temperature, solar radiation, topography, and soil conditions. The biological elements include natural vegetation, plants as well as animals, pests and diseases.
The physical and biological elements determine which crop can be grown in an area (Fig. 2).

Linkage mechanisms between on-farm researcher (NAES), field agents and staff (MoA), and the farmer (FS).

As described above, field agents and on-farm researchers are part of the human environment of the farming system. They are mainly involved in the process of generating new technologies for the farmers. In that process the identification of problems, the transfer and the adaptation of new technologies follow steps in which the field agent plays an **intermediary** role

between the farmer (farming system) and the on-farm researcher (NAES). He acts directly within **the information flow** from the farmer to the researcher (diagnoses for the identification of problems, feed-back for technology adaptation) as well as from researcher to farmer (transfer of new technologies) (Fig. 3).

FIGURE 3: LINKAGE MECHANISM BETWEEN RESEARCHER (NAES), FIELD AGENT AND STAFF (MOA, ACDEP, GGDP,...) AND FARMER (TARGET GROUP FOR TECHNOLOGY TRANSFER).



Constraints and needs in supervision of On-Farm Experiments

The low efficiency in the implementation of on-farm trials encountered with those field agents who carry out on-farm experiments **in addition to their regular duties**, appears to be related to the manifold difficulties encountered in the day-to-day supervision work (Matlon et al, 1984).

For farmers, especially in Africa, extension agents or researchers are representatives of the government. Farmers do not assume that these officials have a real interest in their life or want to improve their way of living. The lack of involvement of farmers in the research process as equal colleagues might be one of the reasons. Participation of farmers can only be expected when their confidence has been gained. This does not only require frequent visits, but also a change of attitude of the extension agent or researcher. Instead of telling the farmer what he needs to do, they must ask him questions and listen to him as a partner. This change of roles is probably more difficult for extension agents than for researchers, as researchers are trained to ask questions whereas

extension agents are trained to instruct" (Steiner, 1987).
But, even if the extension agents are willing and skilled in developing both social and professional rapport with farmers, they are often responsible for a range of regular duties, of which technology transfer is only one so that they often do not have enough time for adequate supervision of on-farm experiments.
The field agents assigned to specific zones or villages are often obliged to work independently and to take decisions without consulting researchers, superiors or other extensionists. In addition, lack of scientific support, adequate resources, training and motivation for supervision and travel are also observed.

These constraints have led to a **linkage problem** between the farmer and the researcher which results in loss of information in two directions (Fig. 3).
First, many trial related information from researchers have not reached the farmers' fields and have got lost (technology transfer). This has led to mistakes during the trial implementation (site selection, lay-out) and during the data recording so that many trials got entirely lost.
Second, important information from the farmers (feed-back and diagnoses) could not be made available to the researcher. This will make the adaptation of new technologies to farmers' conditions and the identification of new problems within the farming systems very difficult.

- First of all, the field agents directly involved in the trial implementation must be recruited with care. They should have a basic scientific and technical know-how as well as the willingness to devlop social and professional rapport with farmers.

- Field agents should have enough time to be able to supervise the on-farm trials regularly and to keep intensive contact with farmers.

- They should receive adequate resources in the form of means of transport (bicycles) and tools for the trial implementation (measuring tapes, field boots, etc.) and for data and information recording (metres scales, field books, etc.)

- Delegation of research tasks to non-NAES agents (Extension or Crop Services, churches, etc...) is a tempting option, because it allows the geographical coverage of research programmes to be increased through the use of personnel in existing research infrastructure.

Nevertheless, there is no substitute for researcher's input in following the seasonal evaluation of the tests, in verifying observations and data registration, and in discussing with farmers and field agents their problems and experiences. OFE cannot be monitored and evaluated from the distance, the researcher's close and frequent contact is absolutely necessary to assure accurate data and valid observations and to maintain the commitment of field agents and especially of the farmers.

- Regular in-service training offered by researchers should provide them with specific trial related know-how.

- Last but not least, an incentive system that reflectsdifferences in working conditions between field- and station-based agents will help to increase their motivation.

Conclusions

In future, the concept of an on-farm research programme based on the whole farming system will become more and more relevant.

The involvement of existing research infrastructure in the case of non-NAES field supervisors in the On-Farm Research Programme can be sustained on a regular basis only if permanent agreements on time, responsibilities, determinations and funds are concluded.

The mechanism which ensures the flow of research-related information between farmers, field personnel and researchers must be improved if the link is to increase the effectiveness of on-farm research.

For the future implementation of the OFR programme, the researchers' responsibility should be allocated to specific farming systems covering specific areas. This results in logistic advantages as well as in an improved knowledge and better understanding of the particular environment in which the farming system and especially the farmers' needs and problems are located.

References

Gilbert, E.H., D. W. Normann, and F.E. Winch, (1980). Farming Systems Research: a critical appraisal. MSU Rural Development Papers. Dept. of Agric. Economics, Michigan State University, East Lansing, Michigan, USA.

Matlon, P., R. Cantrell, D. King, and M. Benoit-Cattin, (1984). Coming full circle: farmers' participation in the development of technology. IDRC, Ottawa, Ont., Canada.

Steiner, K. G. (1987). On-Farm Experimentation Handbook for Rural Development Projects: Guidelines for the development of ecological and socio-economic sound extension messages for small farmers. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn. TZ Verlagsgesellschaft.

Discussion

K.A. HAIZEL

If field agents are overburdened does it mean they should not be used in the on-farm work?

T. del GIUDICE

Of course not. The difficulties encountered in the day to day supervision work of the field agents should be considered to achieve a better efficiency in on-farm experimentation.

P. SALEZ

Feed back from peasants to researchers is really determined by the type of trial you choose (from entirely researcher managed trials to completely farmer managed trials). How do you consider this aspect?

T. del GIUDICE

In fact the type of farm trials (whether researcher managed or farmer managed trials) is related with a different need of feed back from the farmer to the researcher. The feed back from farmers through the field agents will be more important at the researcher managed type of on-farm experimentation process. But the field agents will be more involved in the feed back in farmer managed trials.

H. BAUR, (NAES)

COMMENT: I would like to comment on the question of how OFR is integrating the FAR perspective in its work. It is quite true that applied research at NAES is concentrating on crops only. But as far as FS surveys are concerned we also look into aspects of livestocks off-farm income and so on.

S. TWUMASI-AFRIYIE

COMMENT: The use of planning sessions as a means of prioritizing researcheable problems and daily allocation will make it possible for extension agents to work without being over burdened.

COMMENT: We have to identify field agents who are good and give them the sole responsibility of catering for on-farm trials alone. This way we can take a lot from the hands of the agents.

TOWARDS ACCELERATED AGRICULTURAL PRODUCTIVITY AND OUTPUT IN THE NORTHERN GUINEA AND SUDAN SAVANNA ZONES OF GHANA

A.B. Salifu

(Nyankpala Agricultural Experiment Station)

Abstract

The Northern sector of Ghana which occupies 40% of the total land area of Ghana, lies within the Northern Guinea and Sudan Savanna agroclimatic zones. The sector has been reported as an area of high agricultural potential. The principal constraints to increasing agricultural productivity include declining fertility of otherwise fragile soils, soil erosion, water conservation and improved agronomic practices. In the more densely populated areas, farm land is becoming scarce. Farmers attempt to satisfy family consumption needs by expanding the crop area into more marginal zones. This paper proposes agricultural research and development strategies that would foster increases in farm productivity and output in the crop subsector. Proposals are also made on rapid appraisal techniques for identifying potentials and constraints in agricultural development and research planning.

Introduction

The northern sector of Ghana, comprising the Northern, Upper East and Upper West Regions occupies 40% of the total land area. Agroclimatically, the northern sector falls within the northern Guinea and Sudan Savanna. The Northern Region (NR) falls almost entirely within the Guinea Savanna zone whereas the bulk of the Upper East Region (UER) and the upper fringes of the Upper West Region (UWR) fall within the Sudan Savanna zone. Large variability is a feature of the climate of the whole sector. This variability affects the viability of management of agricultural systems in the sector. Agriculture is practically rain-fed with the probability of success in the Guinea Savanna much higher than in the Sudan Savanna zone (Sanders, 1989).

Agricultural Potential

The Northern Sector has been reported as an area of high agricultural potential. The variety of crops grown in the sector include maize, rice, sorghum, millet, yam, groundnuts, cowpeas, pigeon peas and cotton. The contribution of the sector to the national output is tremendous (Fig. 1). These crops are also produced in surpluses as evidenced from the statistics on the short-falls in production in 1987 (Fig. 2). Together with cotton

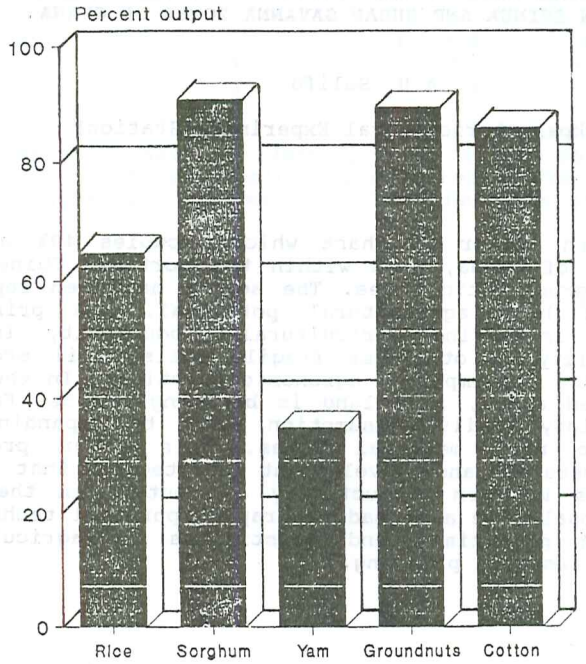


FIG. 1: Contribution of the northern sector of Ghana to national output in 1986 (PPMED & UNDP/FAO, 1987).

which is an industrial crop produced predominantly in the sector, the contribution of the sector in terms of agriculture's contribution to national development may be found in the following areas:

a. providing increased supplies of food and raw materials to meet the needs of the expanding non-farm sectors.

b. earning foreign exchange through production for export

c. providing a net flow of capital to finance part of the investment requirements for infrastructure and industrial growth.

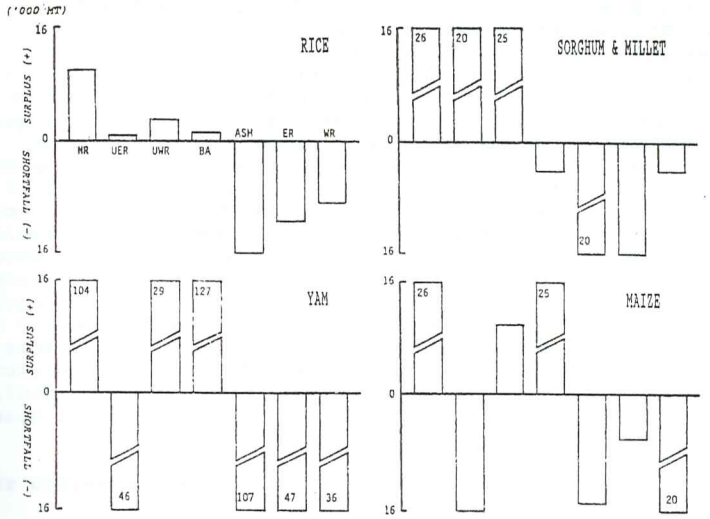


FIG. 2: Shortfall in 1987 domestic production of some staple food crops (PPMED & UNDP/FAO, 1987).

Constraints to production

Despite the potential to meet the nation's food requirement, agriculture in the zone is associated with low productivity as exemplified by the data in Fig. 3. The principal constraints to increasing agricultural producti- vity and output include declining soil fertility, susceptibility to erosion, inadequate water conservation, improper farming practices, lack of improved technology and most importantly lack of credit to maintain a farm enterprise. In the past, the indigenous people practiced the fallow system of shifting cultivation - a productive savanna agriculture patterned on the vegetation that it replaced. However with a high propensity for increase in human population (annual growth rates of 3.4, 2.6, 2.3 for NR, UER and UWR, respectively [Statistical Service, 1989]) the man: land ratio has been worsened to the extent that today in the UER, land can be regarded as scarce.

Proposals for constraint amelioration

Research proposals

Soil erosion and declining soil fertility

The soil is the basis of life for all living organisms and therefore a priced item to guard zealously. Bad land-use including traditional farmer practices are the main causes of erosion and subsequent decrease of fertility in the savanna zone. Furthermore the soils of the savanna (savanna ochrosols) are inherently fragile and susceptible to erosion and degradation. The problems of declining soil fertility, soil erosion and degradation are often related and therefore strategies to combat them are also often similar and generally referred to as conservation.

A conservation production system is achieved when high current production and sustained long-term soil productivity are ensured (Allmaras et al., 1985). Conservation tillage keeps crop residues on or near the surface. The aim is to produce a rough soil microrelief, or to minimise erosion and improve soil-water relations.

In order to tailor an appropriate conservation tillage practice for the zone, it is suggested that the Soils Research Institute (SRI) in conjunction with the Crops Research Institute (CRI) demarcate the zone into what would be referred to as Tillage Management Districts (TMD). These districts would then be subjected to initial diagnostic studies relating to appropriateness or otherwise, of the following techniques of soil conservation: agronomic measures which relate to the role of crop cover; soil management including the use of fertilizers and tillage practices, including animal traction, and mechanical protection works such as contour bunding. As more information is developed these TMDS can be subdivided or new ones created. Efforts would then be concentrated on location-specific land-use problems. Hence the tendency to prescribe blanket remedial actions would be obviated.

One way of ensuring sustainable agricultural produc- tivity is restraining agriculture on land less suitable for it. Therefore in place of the proposed TMD approach, it would be pertinent to map out the area on the basis of land use and/or erosion hazard.

Water Conservation

Agriculture is practically rainfed in the savanna zone. Rainfall is erratic and limited. Water harnessing techniques are hardly employed deliberately by farmers to conserve water. The situation is exacerbated by excessive run-off which consequently causes erosion. As land lies bare and untilled the rate of infiltration is considerably lowered. There is therefore the need to investigate and find ways of improving tillage systems aiming specifically at water conservation.

There is potential for small-scale irrigation in the savanna zone. There are quite a number of low lying areas endowed with fertile soils where these smallholder irrigation schemes could be exploited: Fumbisi valley, Nasia, Fuu, to mention but a few. It is unfortunate so far, not much action has been expedited along these lines yet. It is important to state that reference is not being made to irrigation "megaprojects" necessitating high costs and huge investments, but simple systems of weirs, bunding etc.

Improved crop technology

Research at the Nyankpala Agricultural Experiment Station (NAES) has demonstrated the beneficial effects of crop rotations. In parts of the UER where land pressure is most acute, continuous cropping (without rest periods of rotations) are exhaustive of soils and consequently, crop rotations would be a valuable component of the cropping system. The results obtained at NAES would need to be packaged appropriately for demonstration on-farm.

Lack of improved crop varieties constitutes part of the agronomic constraints to the problems of agricultural productivity in the savanna zone. Crop breeding strategies in the zone must emphasize drought-tolerant early-to medium maturity varieties. When such varieties have been synthesized, there must be a mechanism to enable their dissemination and maintenance of purity. In other words a viable seed service is paramount.

Pending the establishment of an authentic seed industry (in the aftermath of the dissolution of the Ghana Seed Company (GSC), research (that is CRI) and the Ministry of Agriculture can cooperate in varietal maintenance and initial seed increase to ensure supply of Basic Seed for multiplication. In planning the production of basic seed it is necessary to consider how to supply farmers with genuine seeds of varieties. One option would be to supply basic seed to selected growers and seed enterprises (if there are any) who then multiply it and market certified seed or commercial seed to farmers. This system stimulates interest in seed production and marketing among individuals and enterprises. An equitable screening system may also be deviced in which basic seed of new varieties are allocated only to those farmers or enterprises who produce excellent seed.

Demonstration schemes

The reason farmers often cling tenaciously to inferior traditional varieties and/or farming practices is that improved techniques have often not been demonstrated to them or at best inadequately represented. To encourage farmers in the use of holistic and scientific approaches to boost up agricultural production, a Regional/District Demonstration Scheme is proposed. These demonstrations are envisaged along the lines of Regional/District Agricultural Shows and are intended to demonstrate the production potential and economic viability of new technologies. These may be achieved through:

a) SINGLE CROP demonstrations covering essentially, rainfed crops, e.g. sorghum, millet, maize, cotton;

b) Rain-fed INTER-CROP, e.g. Millet/cowpea, Maize/cowpea

c) Where irrigation facilities exist TWO-CROP SEQUENCE, e.g. cowpea before rice, maize after cowpea.

The successful operation of this scheme would depend on the successful and meaningful cooperation and coordination between research and the Ministry of Agriculture (Crop Services and Extension).

Agroforestry

In the savanna zone the clear-cutting of trees for fuel wood and roofing poles coupled with annual bush fires and improper land clearing for agriculture has denuded a greater portion of agricultural land. Agroforestry, the integration of trees into cultivated fields or farming systems to improve soil fertility and microclimate, prevents soil erosion and produce fuel wood, timber, fodder or edible products. Agroforestry would be a valuable option to countenance degradation in the savanna zone. It is the ecological effects of trees that form the distinctive feature of agroforestry and distinguishes it from social forestry.

In advocating agroforestry, it is assumed that research would first be conducted to identify suitable agroforestry systems for the savanna zone. Special emphasis should be placed on nitrogen-fixing trees to increase natural and low cost inputs of the important nutrients into the production system. Some important institutional questions to anticipate include: Does the traditional land tenure system work in favour of or against agroforestry systems? If against what modifications are required to make the system acceptable? What combinations of economic and policy means are needed to hasten the adoption of agroforestry systems by farmers?

Losses due to pests and diseases

Almost every crop grown in the savanna zone is subject to insect and disease ravages at various stages of growth and development. The pest problems continue in storage. Therefore it is essential to focus research on strategies to minimise pest damage both in the field and in storage. Such strategies should include integrated pest suppression techniques that combine natural control with artificial methods. The first step should be a full appraisal of field pest problems <u>in situ</u> on farmers fields. This way it would be possible to formulate pest control strategies that take into account farmers' circumstances.

The main causes of postharvest losses are improper and inadequate product handling, drying and especially, storage methods employed on farms and in dwellings. Research is required on postharvest losses, especially in terms of sufficiency of traditional storage devices in relation to improved crop protection practices.

Credit

Agricultural technology packages do not come free. Increasing farmer output requires purchase of inputs and adoption of new technologies. Credit is only part of a package of inputs and services required to improve farm productivity.

Certainly one major cause of low agricultural productivity in the savanna zones is farmers' lack of collateral for conventional bank loans. This knowledge should help agricultural policy makers and bankers alike to device borrowing strategies which overcome the lack of collateral, or which remove the need for collateral or which go round the need. These may be achieved by government guarantees on loans or by the creation of alternative source of funding through cooperative credit schemes.

Marketing

A fundamental argument relating to commodity prices is that farmers respond to price increases by raising production; and conversely, that production will not increase unless prices are remunerative. For agriculture to be regarded as a worthy enterprise and therefore successful, farmers must be able to sell produce at least to pay for implement and other inputs. The price incentive is certainly a key factor to consider. Therefore policy makers would at least consider that the price of inputs must be proportionate to the benefits gained when making decisions on the minimum guarantee prices for agricultural commodities.

Local trade in the savanna zone is dominated by private and competitive trading in town and village markets where small quantities of produce are brought on market days to be sold directly or through middlemen. The dubious tendencies of some middlemen cannot be over-emphasized. Therefore to help farmer fetch good prices for their produce the Ghana Food Distribution Corporation should be funded adequately to remain competitive.

Communication

Lack of proper communication between institutions engaged in agricultural development is one subtle cons- traint that is often overlooked. Communication gaps appear between research and policy makers in one case and between research and extension in the other. It appears the trend is that of each of these actors vibrating individually and separately, on different frequencies; hoping to come in odd resonance with the other party. What we need to do is to stop vibrating and start to communicate. As far as research/policy maker interaction is concerned the onus is on us to communicate the methods and possible outcomes of our work to the public at large. Much more cooperation is needed between research and the Ministry of Agriculture in the formulation of guide-lines for establishing targets and priorities for agricultural research and development in the savanna zone.

Coordination of agricultural and agriculture-related projects

Several NGOs and formal institutions are engaged in agriculture and rural development in the savanna zone. To derive maximum benefit from the efforts of these organisations there is a need for central coordination of their activities. Coordination will facilitate proper inter-organisation communication, spell out domains of operations and more importantly resources, both human and material, will be utilized efficiently. In this regard it is suggested that agricultural administrators consider setting up a coordination unit/office in areas where several organisations operate.

Development proposals

Agro-based industries

The savanna zones produce the bulk of Ghana's cotton, groundnuts, rice and a variety of other economic/industrial crops (Fig. 1). Unfortunately there are very few agro-based industrial plants in the region. The Tamale Vegetable Oil Mills with an installed annual capacity of 2,000 metric tonnes is currently on divestiture. Its fate is not fully determined yet. There is a need to reactivate this mill and other industrial plants with similar predicaments in the zone; it would also make economic sense to set up more industrial plants like a spinning mill to make use of the large amount of cotton produced in the zone. The establishment of such agro-based industries would not only promote social justice and stimulate local entrepreneurship, it would offer employment opportunities which in turn would go a long way to alleviate the abject poverty that is common in this part of Ghana.

Education

Much has often been said about the imbalance in education between the northern and southern sectors of the country. The major cause of this imbalance is tied with poverty, the colonial factor of deliberate withholding of education for indigenes of the northern sector notwithstanding. Most parents are unable to send their wards to school because they are poor. The result is a high proportion of people with little education which in turn leads to less economic activity and therefore poverty again.

A massive drive to get enrolment up is required. Aside from compulsory enrolment, parents need to be educated on the need and benefits of getting educated. In this regard the Ministry of Education could solicit the support of the Ministry of Information and the Centre for National Culture to produce movie clips of dramatised scenes demonstrating the importance of going to school. These would then be shown in the rural areas as was done in the sixties and early seventies.

Constraint and prospect appraisal for research and development

In order to improve the traditional cultivation techniques of small farmers and support their economic viability, it is necessary to identify constraints and potentials rapidly and adequately. Rapid appraisal techniques that may be employed by researchers and agricultural administrators in pursuit of this objective include Agroecosystem Analysis (Conway, 1985; 1987) and the Sondeo (Hildebrand, 1981). The important attribute of these techniques is the use of a multidisciplinary team - agronomists, socio-economists, entomologists, administrators and even farmers - in the appraisal exercise. It is however very important that members of the multidisci- plinary team be well trained in their own field and have the desire for forging a working understanding of each other. The use of the multidisciplinary team serves to provide information from different points of view simultaneously.

References

Allmaras, R.R., Unger, P.W. and Wilkins, D.W. 1985. Conservation tillage systems and soil productivity, pp. 358-404. In Soil Erosion and Crop Productivity. Follett, R.F. and B.A. Stewart (Eds.). American Society of Agronomy, Crop Science Society of America & Soil Science Society of America. Madison, Wisconsin.

Conway, G.R. 1985. Agroecosystem analysis. Agricultural Administration, 20: 31 - 35.

Conway, G.R. 1987. The properties of agroecosystems. Agricultural Administration, 24: 95 - 97.

Hildebrand, P.E. 1981. Combining disciplines in Rapid Appraisal: the sondeo approach. Agricultural Administration, 8: 423 -432.

PPMED and UNDP/FAO, 1987. Final report on annual sample survey of agriculture, Ghana, 1986.

Sanders, J.H. 1989. Agricultural research and cereal technology introduction in Burkina Faso and Niger. Agricultural Systems, 30: 139 -154.

A CONCEPTUAL FRAMEWORK FOR RESEARCH PLANNING, MONITORING AND EVALUATION (M+E) AT NAES

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Introduction

The aim of this paper is to highlight the importance of formalized procedures in planning, monitoring and evaluation of farming systems research. The farming systems research approach, if it is successful, has a strong farmer orientation and encourages the contribution of a range of development institutions and research disciplines in addressing high priority problems of the farmers. However, where should the farmer orientation and effective linkages come from?

A strong farmer orientation and effective linkages between different research disciplines and different institutions are not likely to develop on a 'hoe basis'. Although the notion of client orientation in agricultural research is common sense, developing efficient management methods for achieving the orientation is often quite difficult. Imperfections in the logic and coordination of experiments or surveys continue to be a cause for wasted resources in many research programmes (Byerlee and Tripp, 1988). Information transfer from research to the farmer through extension is usually not well developed. And the feedback of problems from the farmer to research is almost non-existant in practice.

It is also frequently felt that farming systems research should contribute more to the identification of development objectives and formulation of policies, to the integration of applied and adaptive research, and to the creation of a common sense of mission shared by different kinds of research staff and development workers (Nickel, 1988; Merril-Sands, 1988; Byerlee and Tripp, 1988).

One of the reasons for these shortcomings is that many farming systems research programmes pay little attention to the development of appropriate methodologies for programme formulation, monitoring and evaluation procedures. Progress in research methods such as survey techniques or experimental designs and analysis have not been matched by the development of mechanisms by which implementing agencies and farmers are able to participate in the research process.

A stepwise approach to research planning

Research programme formulation and control are vital steps in agricultural research. It is important that research objectives are in line with national agricultural research and development plans and to compare the progress of work against planned objectives. For NAES, research policy guidelines are

made by the Steering Committee based on national development policies and relevant information supplied from the station. Within these guidelines, however, there is ample room for the choice of experiments or studies by the individual scientist. Although it is clear that the problems to be solved are those of the farmers, experience shows that there is a need for some formalized procedures at the different stages of the research process (Content and Bottomley 1988; Dagg and Hayworth, 1988; McLean, 1988). It is therefore important that,

a) Technical solutions to be generated by applied research have to address the real problems of the farmers. These solutions have to be compatible with the competence and resource endowment of extension and supply systems. It is also important to involve implementing agencies in the early stages of research planning.

b) Because not all research proposals are of the same relevance and because time of trained manpower are limited there is a need for review and priority ranking of proposed research projects.

c) Because timely information is a pre-condition for corrective action at the research management level, there is also a need to follow up research progress, the use of resources and research results.

Involvement of implementing agencies

To involve implementing agencies in research planning, informal relationships are not sufficient due to spatial separation of the institutions, differences in the professional definitions and role perceptions of the personnel involved.

At the Nyankpala Agricultural Experiment Station, the Extension and Crop Services Departments of the Ministry of Agriculture and non-governmental organizations participate in programme formulation through their representatives in the Steering Committee and through joint planning meetings which are held at the beginning of the annual planning process. These meetings seek to identify relevant problems as perceived by these implementing agencies and to focus research accordingly. Participation in the planning process is particularly important for the planning of the on-farm research programme because the Crop Services Departments are also conducting on-farm tests.

Our experience from these joint planning meetings is encouraging although the preparation of the meetings could probably be improved. Farmers, however, are not yet involved in the planning and we don't know yet how this could be done in

future. There is a lot of literature about farmer participation but most of it is based on rhetoric of intent rather than practical experience. Finding practical solutions to improve the direct involvement of farmers in the planning is still on the agenda. Feedback of farmers' problems and constraints to the station is secured by the On-Farm Research Section.

A plea for a Farming Systems Research Committee

Up to now, research projects proposed by the individual scientists at NAES were reviewed at the annual In-House-Review before they were implemented. Although there is nothing wrong with this procedure where the rational and technical design of experiments is reviewed, there is a missing link between the planning meetings and the technical review. As the research capacity of the station is increasing, there is growing need for a collegiate structure to improve inter-disciplinary communication and programme formulation. The objectives of such a scientific committee would include:

- to provide a forum for inter-sectional communication and eventual understanding.

- to reinforce the farming systems perspective as the major orienting principle of research activities or, in other words, a common value system, which has been found to be of crucial importance in other areas of professional activity (Nickel, 1988; Peters and Waterman, 1982).

- to review research proposals for relevance and priority in order to bring the final programme in line with available financial and human resources.

- to coordinate research activities to bring about a unified research programme.

Such a committee should consist of a multidisciplinary group of senior research staff, supplemented again by representatives of extension and other development agencies. It should be broad enough to give a good disciplinary spread but also small enough to conduct business efficiently, certainly not more than 20 members.

Review for relevance would have to refer to the urgency and usefulness of the information that the experimental data might lead to. Naturally, the urgency and usefulness will depend on the need and judgement of particular clients like regional planners, farmers, consumers, extension workers and also fellow scientists. Although informal communication is also highly valuable in this area, arguments for a formalized procedure for assessment and priority setting are numerous.

As rural development lags, more and more is expected from agricultural research. But expectations are often unrealistic, in particular when looking at manpower development, funding and also organizational capacity. Formal priority setting can reveal where unrealistic expectations lie.

Research organisations confronted with conflicting goals need methods to make decisions as well as arguments with which to defend them. A planner who has gone through a systematic review and priority setting exercise is in a much better position to defend his decisions on his priorities. Moreover, a formal method of comparing different research proposals, can help to change priorities more easily, if necessary.

Since the number of scientists is limited at a station like NAES, it is sometimes difficult to generate the critical mass needed to tackle important research topics. Techniques to decide where to concentrate resources are therefore valuable.

Formal priority setting also helps to determine a rational division of research efforts between institutions. A formal review process can include policy considerations more systematically than an informal one. It can address such issues as the potential for foreign exchange earnings or the effect of research on income distribution or the benefits to consumers. Formal priority setting will also identify points where personal research agendas and national interests appear to be in conflict.

Priority setting by itself is no guarantee for successful research. Other factors like the quality of the scientists involved, the stability of structures and reliable source of funding are just as important.

Criterial for the review of research proposals in the proposed FSRC could be:

- the potential impact of the perceived research output on the economy of the mandate area regarding e.g. area affected, demand for the commodity, urgency of need, or impact on the environment.

- the chances for a successful outcome and the costs involved of the research by considering the availability of trained researchers and the duration of the project.

- the feasibility of using the research output to increase production or productivity. The application of this criterium would have to consider whether the type of solution envisaged can be implemented by farmers and the development agencies supporting them, likely rate of adoption, efficiency and effectiveness of development and input supply services, and risk to producers.

If a research proposal is to be discussed adequately, it must be well documented. Therefore, every research project presented at the FSRC would have to be based on an acknowledged research protocol. This is not only to justify spending of research funds but also for securing appropriate research at NAES and facilitate monitoring and evaluation of activities.

For review at the Farming Systems Research Committee, this documentation must include at least

- a brief outline of the background and problem and a statement why the research is needed.

- the hypothesis and precise objectives of the research including expected outputs, indicators of achievement and a statement about the relevance of potential results.

- a cost estimate.

The In-House Review is still important

After review at the Farming Systems Research Committee where the discussion is about what to do and why, research proposals would still have to be presented at the In-House Review.

This would be the third and last step of the planning process where it is discussed how readily, reliably and efficiently the proposed experimental design or survey will yield the data targeted.

Monitoring and evaluation begins with planning

At NAES, no systematic monitoring has been done in the past. But there are good reasons to introduce M/E into the research system now. First of all, FSR is information intensive and needs a lot of data gathering and communication. Monitoring and evaluation activities are primary means of collecting and analysing information for management purposes. Monitoring results permit management to compare progress of work against planned objectives and to take corrective action if necessary. It also permits the improvement of future planning and it is essential for evaluations.

It is evident that monitoring is only possible where research has been properly planned and documented. Progress of work can only be measured if objectives and indicators for achievement have been set at the planning stage. But surprisingly, objectives and indicators are often not clearly stated but implicitly assumed.

It is therefore suggested to strengthen planning procedures at NAES so that research protocols can be used as a basis for monitoring and evaluation. This would need a research planning model with formalized research protocols. A standard format would facilitate discussion at the planning stage as well as recording and analysis for monitoring.

Apart from input monitoring, emphasis should be on

- activity management
- individual workplans of research staff
- data utilization procedures

- collaboration with other scientist and/or institutions
- reporting schedules
- and communication channels for results.

References

Byerlee, D.; R. Tripp, 1988: Strengthening linkages in agricultural research through a farming systems perspective: The role of the social scientists. Experimental Agriculture 24:137-151.

Constant, R.B.; A. Bottomley, 1988: Priority setting in agricultural research ISNAR Working Paper No. 10, The Hague.

Dagg, M.; F. Haworth, 1988. Programme formulation in national agricultural research. ISNAR Working Paper No. 17, The Hague.

de Haen, H. et al. 1985. Evaluation of the Nyankpala Agricultural Experiment Station/Ghana. Goettingen.

McLean, D 1988. Monitoring and evaluation in the management of agricultural research. ISNAR Working Paper No.14, The Hague.

Merill-Sands, D. and J. McAllister, 1988. Strengthening the integration of on-farm client-oriented research and experiment station research in national agricultural research systems (NARS): Management lessons from nine country case studies. The Hague: ISNAR.

Nickel, J.L. 1988. Excellence in agricultural research. Agricultural Administration and Extension 28:43-58.

Discussion

H. RUDAT

Why do we need a Farming Systems Research Committee? The Steering Committee meets once a year, likewise the In-house-review. What we need besides this is a formal gathering of scientist in form of a general research committee in order to form a basis of continuous research discussions (1-2 times a month). By having this we can relate our work to limited resources (money, manpower, logistics etc.) and can make sure that any research proposals is handled properly.

D.K. ACQUAYE

Basically the research activities of NAES are in the area of farming systems for Northern Ghana. As such I expect that there is internal disciplinary consultation among the research scientists. What is therefore the need for a Farming systems Research Committee? Is it a national committee or an internal committee?

H. BAUR

The Farming Systems Research Committee suggested would basically be an internal forum, supplemented by a few representatives from other institutions.

Of course there is internal consultation and communication at NAES but with informal communication it is not possible to prioritize research proposals nor to assess their relevance. The FSRC would have to discuss what is to be researched on and why. It's decisions should be based on consensus.

FARM-HOUSEHOLD DECISION MAKING WITH RESPECT TO THE ADOPTION OF AGRICULTURAL INNOVATIONS - PRELIMINARY RESULTS OF A VILLAGE LEVEL CASE STUDY IN THE UPPER REGIONS

Artur Runge-Metzger

Introduction

Generally, before agricultural technologies are transferred from the research station to farmers' fields economic feasibility of the new technology is supposed to be evaluated. In the recent past economic assessment of agricultural innovations has increasingly been based on technical input-output coefficients such as yields and labour requirements obtained under on-farm conditions. Furthermore, it is usually assumed that farmers will accept a certain innovation if it is profitable enough. The assessment of profitability of new technologies is mainly based on partial methods of analysis. Such methods normally include production function analysis, gross margins analysis and/or benefit-cost-analysis. Opportunity costs of labour and capital used in the calculations in most cases simply reflect observed wage rates of rural labour and interest rates of official banks, respectively. Moreover, calculations are predominantly carried out for so called representative farms. During the past, doubts have been raised whether the results of partial analysis can be used to predict adoption behaviour of small-scale farm households.

Therefore in the following paper it will be examined how far simple calculations of profitability of selected innovations are able to explain actual adoption behaviour. Data are taken from a survey carried out in two villages of the Upper Regions. The study, in general, aims at

- identifying the potential benefits of selected innovations at the farm level,
- improving the knowledge about current levels of adoption of certain agricultural innovations,
- arriving at a better understanding of the decisive variables in farmers decision making process,
- improving the methodology of technology evaluation.

The paper is divided into four sections. Firstly, the farming systems of the study area will be described briefly. Secondly, profitability of four different agricultural innovations will be examined, and results will be compared to actual adoption behaviour. Thirdly, probit and tobit analysis will be used in order to identify determinants of adoption. Finally, results will be discussed and suggestions will be made considering possible improvements research methodology. Moreover some proposals with respect to policy design will be presented and areas of further research will be identified.

Study area

The study was carried out in two villages, one located in the Tumu District(Sakai) and the other in the Navrongo District (Koronia). In total, 44 households were surveyed over a period of 13 months in 1987/88. Basically, the two districts vary considerably with respect to the population density. This has significant impacts on the existing farming systems as can be seen from Table 1. In the area with the low population density, household heads are found to be older and families are constituted of more persons. Moreover, the number of consumers per household is higher in the sparsely populated area than in the area with the high population density. With increasing population density land becomes more scarce so that it is not surprising that more consumers have to be fed from one hectare in the Navrongo District than in the Tumu District.

In Navrongo, land scarcity led to the reduction of fallow periods. At present, a major proportion of the farm, in particular the compound farm, is already under permanent cultivation. When soil nutrients are not fully replenished the reduction of fallow periods usually results in the decline of soil fertility. Subsequently, farmers in this area try to maintain soil productivity by using organic manure, and by increasing labour intensity. However, crops which require fertile soils like e.g. yam and maize can no longer be cultivated (Figure 1). Despite these efforts to maintain soil fertility, soil productivity per hectare of cropped land is significantly lower in the highly populated area as compared to the sparsely populated area. In the Navrongo District less than 10 Gigajoule (GJ) are produced per hectare while it is approximately 17 GJ/ha in the Tumu area.

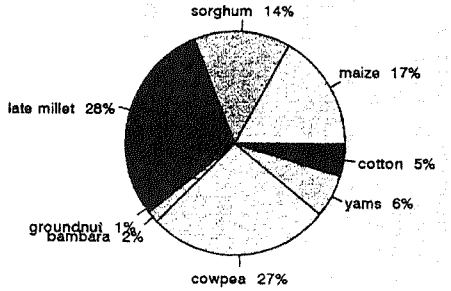
In the highly populated area as more people have to be fed from one hectare, current annual production amounts to 3.6 GJ per consumer. Obviously, on average, crop production hardly meets the yearly calorie requirements of one consumer (3.9 GJ/consumer according to FAO Standards).

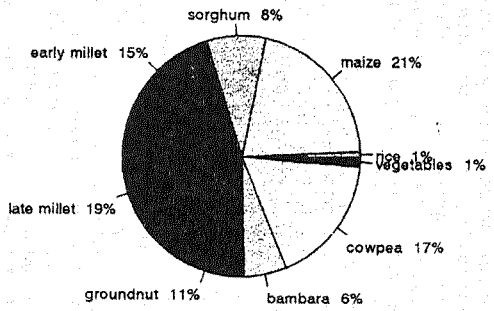
As plant production does not provide sufficient food for the majority of farm households, crop production income has to be supplemented by earnings generated from non-farm activities. In the Navrongo District, almost 10 % of the household income is generated by off-farm activities while they are negligible in the Tumu District. However, off-farm employment opportunities are very limited in the study area. Therefore more than one-third of the households located in the area under high population pressure reported that at least one household member has permanently migrated to the South.

With respect to the supply of agricultural inputs, farm households of both villages face favourable conditions as compared to the majority of villages in the Upper Regions. In both study villages a Farmers Services Company (FASCOM)

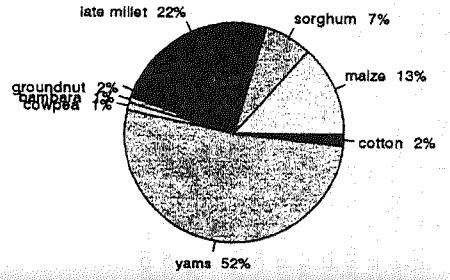
Figure 1: Cropping Pattern of the Two Study Villages, 1987/88

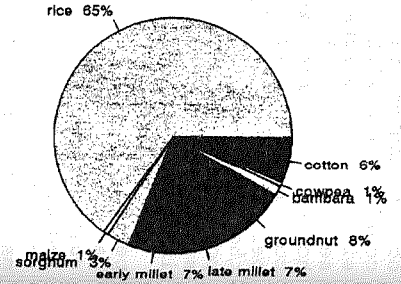
Tumu | Navrongo





a) in percent of total cultivated area





b) in percent of total gross returns

Fig. 1:

store can be found[1]. Village selection was done purposely in order to ensure that a sufficient number of adopters of the new technologies are available for a random selection. Furthermore, only those innovations which had already been introduced to the region a couple of years before, were included in the survey.

TABLE 1: MAIN CHARACTERISTICS OF THE FARMING SYSTEMS OF THE SELECTED VILLAGES, 1987/88

Village District	Sakai Tumu	Koronia Navrongo
Annual rainfall (mm)[1]	1065	1033
Population density (pers./km2)[2]	9	92
Age of household head[3]		
- 40 years	27 %	56 %
41 - 60 years	41 %	33 %
61 - 80 years	21 %	10 %
> 80 years	11 %	1 %
Household size[3]		
- 5 persons	29 %	42 %
6 - 15 persons	53 %	53 %
> 15 persons	18 %	5 %
No. of consumers[4]	9.2	5.1
Consumer-Land-Ratio (cu/ha)[5]	1.9	4.3
Value of cattle/consumer (C/ha)	21777	15761
Total Labour Input/ha (md/ha)	137	301
Family Labour/man-equiv. (md/me)	138	105
Soil Productivity (MJ/ha)	16660	9954
Yield per Consumer (MJ/cu)	10795	3554
Gross Returns		
- crop production (C/cu)	65333	40938
- livestock prod. (C/cu)	10223	-499
Farm Income/Consumer (Cedis/cu)	71446	31465
Household Income/Consumer (C/cu)	71821	34517
Share off-farm income	1 %	9 %
Households with members permanently absent	5 %	34 %

1) Regional Meteorological Office, Bolgatanga (1988)
2) Central Bureau of Statistics (1984)
3) Baseline survey data
4) Following figures are estimated from household data.
5) Acreage under fallow is excluded.

1 On the basis of a regional survey, the impact of the distance between a supply center and the farm household on the adoption of new agricultural technologies has been investigated separately. Results will not be reported here.

Generally, the selected innovations differed with respect to their expected impacts on land and labour productivity, their complexity and their lumpiness in order to find out whether relative superiority of the technologies varied in accordance to household's relative resource endowment. The innovations under investigation included the use of mineral fertilizer, bullock traction, irrigated rice farming and cotton production. Irrigated rice farming and cotton production are new crop enterprises. While mineral fertilizers are supposed to be a land-saving technology, bullock traction is expected to be a labour-saving technology. In the following chapter, partial analysis of profitability will be carried out and results will be compared to actual rates of adoption of the various technologies (Annex A).

Partial Analysis of Profitability

Mineral Fertilizer

Farmers prefer to apply fertilizer to those crops which have shown an elastic response to the application of fertilizers. In the Navrongo District, fertilizer is predominantly applied to rice and vegetables, while farmers in the Tumu District preferably use fertilizer on maize and cotton. Optimum rates of mineral fertilizers are determined by production function analysis. Production functions are estimated from plot level data of farmers' fields (Annex B).

Table 2 shows optimum fertilizer rates for dry-season rice (Navrongo District) and for cereal dominated crop mixtures in the Tumu area. In both cases, the results show that fertilizer application increases yields substantially. In particular, irrigated rice shows an elastic response at higher dosages of fertilizer. Optimum levels for irrigated rice are four to five times higher than for rainfed cereal mixtures in the Tumu District. It has also to be noted that optimum fertilizer levels for cereal mixtures in the Tumu area as indicated by the production function analysis are below fertilizer recommendations disseminated by the extension service.

Furthermore, optimum rates of fertilizer depend on the ratio between product and input prices. As product prices vary in accordance to the season, optimum fertilizer levels vary according to farmers price expectations. Therefore optimum fertilizer rates are determined in accordance to seasonal variation of product prices. When farmers average practices are compared to the optimum levels, farmers in the Tumu area apply fertilizer at a rate which is close to the optimum rate under low price conditions (Table 2). In

TABLE 2: THE IMPACT OF MINIMUM, MAXIMUM AND AVERAGE SEASONAL PRICES ON OPTIMUM FERTILIZER DOSAGES FOR CEREAL-LEGUME-MIXTURES (SAKAI) AND DRY SEASON IRRIGATED RICE PRODUCTION (KORANIA), 1987/88

	Product price Pp C/kg	C/MJ	Fertilizer price pi C/kg N1)	pi/Pp	Optimum rate kg N/ha	farmers' practice kg N/ha
Sakai	28	1.86		72.6	26.3	
	80	5.31	135.1	25.4	35.7	27.8
	49	3.22		42.0	31.9	
Korania	117	7.97		14.0	120.6	
	162	11.1	111.6	10.1	125.2	90.9
	139	9.48		11.8	123.2	

1) Average nutrient ratio applied: Sakai, 28-14-14 NPK; Korania, 91-31-19 NPK.

the Navrongo area, average actual fertilizer dosages are significantly below the optimum amounts.

So far, the analysis was based on average data across different households. However, in reality different farm-households may face different fertilizer prices (different sources, different costs of transportation etc.) as well as they may face different crop prices (e.g. due to different times of sale and consumption). Therefore data are analyzed on an individual basis. According to economic theory optimum fertilizer rates are applied when the input-product price ratio equals the marginal physical productivity. Therefore optimum rates of mineral fertilizer are plotted against the actual rates for the individual farmers (Fig. 2). Apparently, most farmers apply mineral fertilizer at rates far below the optimum. Only few farmers operate close to the optimum. This indicates that farmers could still increase their incomes substantially by applying more fertilizer. Moreover, it has to be noted that 20 % of the farm-households surveyed in the Tumu District and 30 % of the farm-households in the Navrongo District did not use any fertilizer in 1987/88 (Annex A).

Bullock traction

Basically, bullock traction is a long-term investment. Benefits and costs are distributed over several years. Therefore multiperiod investment analysis has to be carried out in order to assess profitability of the use of oxen technology. As bullock traction is a complex innovation several changes of the traditional hoe farming system can be expected when bullock traction technology is introduced.

Figure 2: Optimum vs. Actual Rates of Mineral Fertilizer

1987/88

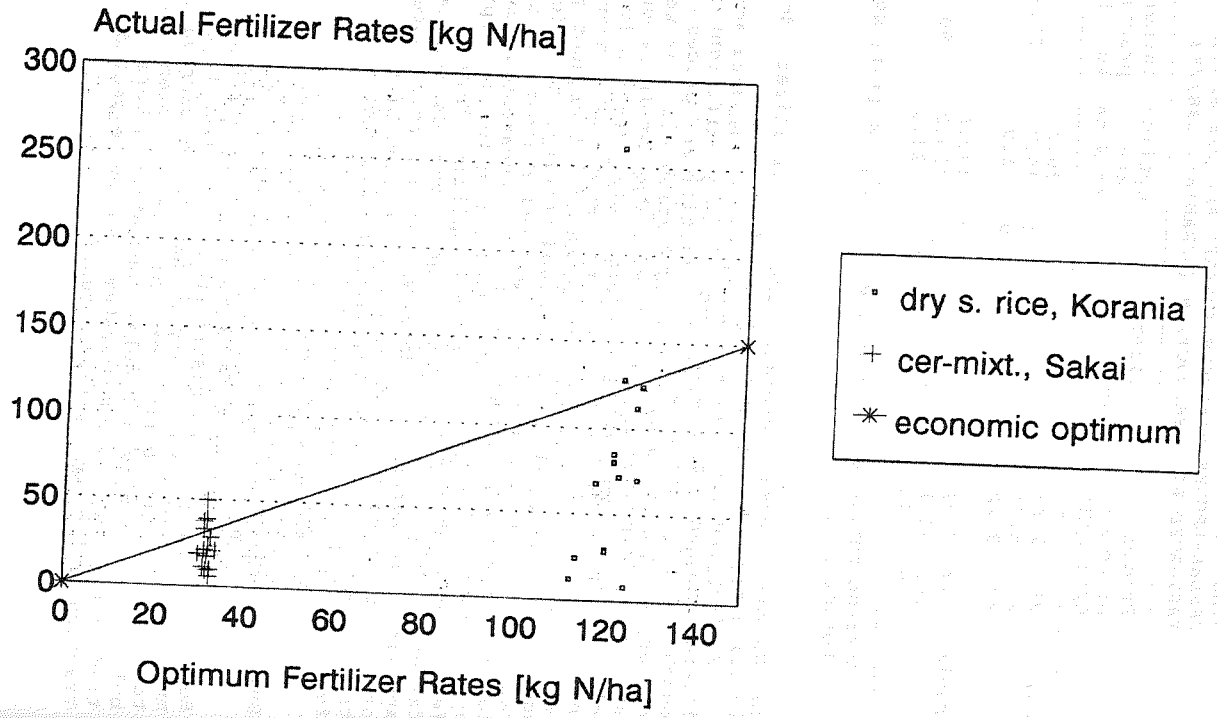


Fig. 2:

In this study variables and figures entering the benefit-cost analysis (BCA) are derived from cross-sectional farm-household data. Possible effects on farm acreage, crop yields, and labour allocation have been estimated by multiple regression analysis.

Generally, the impact of animal traction on the adopting households differ substantially between the two villages. In the sparsely populated area (Tumu), bullock traction households are characterized by

- lower labour intensities per hectare,
- larger acreages cultivated per man-equivalent,
- higher crop yields per hectare as compared to their hoe counterparts.

In the densely populated area (Navrongo), bullock households have

- a lower labour intensity per man-equivalent,
- and generate extra income through the provision of bullock services as compared to hoe farmers.

With respect to the adoption of bullock carts it is observed that in the densely populated area a cart is only of limited value to many households. Here, settlements are scattered over the whole area. The land between the dispersed compounds is almost completely cultivated during the wet season. As land is extremely scarce foot paths are very narrow so that bullock carts cannot pass during the growing season. Only few compounds which are located along broad cattle trails or close to the major roads have the opportunity of using the cart throughout the year. Therefore it is assumed that Navrongo farmers do not purchase a bullock cart.

In the area with the low population density, benefit-cost analysis[2] shows that investment (bullocks, plow, cart) would be highly profitable for the average non-adopter household. Depending on the scenario internal rates of return range between 4 % and 262 % as can be seen from Table 3 (Tumu).

In the densely populated area, investment in bullocks (bullocks plus ridger) will be profitable for non-adopters only when the labour saved can attract a wage rate of 343 Cedis/manday. This seems to be impossible because the average daily wage rate was only 112 Cedis/md in 1987/88. Investment will only be profitable for larger farm households. They can use bullocks more intensively. But still, the internal rate of return is only 6 % (Table 3, Navrongo, Scenario 1). Profitability can be further increased through the provision of bullock services to neighbours. However, it has to be noted that most of the animal traction households in this area had oxen

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[2] The basic scenarios can be found in Annex C and D.

Table 3: Sensitivity Analysis of Bullock Traction Investment, 1987/88.

Scenario	Assumption	Internal Rate of Return	change in labour utilization2)	wage rate (C/md)3)
TUMU				
0.1	oxen utilization4): 0.5 d	4 %	4 (3%)	
0.2	1 d	21 %	8 (6%)	
0.3	2 d	56 %	15 (11%)	
0.4	3 d	102 %	22 (16%)	
0.5	4 d	165 %	29 (21%)	
0.6	5 d	262 %	36 (25%)	
1	reduced slope of the learning curve (max. acreage in the 4th year)	37 %	15 (11%)	
2	Investment costs + 50 %	31 %	15 (11%)	
3	reduced slope of learning curve and investment costs + 50 %	22 %	15 (11%)	
4	Yield increase (5 % p.a. in the first four years) and reduced slope of the learning curve	109 %	15 (11%)	
5	Yield increase (5 % p.a. in the first four years)	153 %	15 (11%)	
NAVRONGO				
0		5 %	-2.5	343
1	2.4 male-me, 3.6 cu/male-me	6 %	-	-
2	Doubling of ploughing service	7 %	-0.2	-
3	Doubling of utilization rate	12 %	-5.2	112
4	Doubling of ploughing services and utilization rate on own farm	15 %	-2.9	
5	Population density 1960, 57 pers./km2	65 %		-

1) Detailed benefit-cost analyses can be found in Annex C and D.
2) Relative change in parentheses.
3) Only applies to Navrongo where labour is set free.
4) Number of days (1 day=8 hours of work) oxen are used for soil tillage operations.

technology introduced in the early sixties. At that time population density was considerably lower, so that land was most likely not as scarce as nowadays. Under these conditions extension of farm land might still have been possible. If this is taken into account, a satisfactory rate of return of 65 % (Table. 3, Navrongo, Scenario 5) can be realized.

However, when one looks at the rates of adoption, it can be seen that despite the high profitability of the bullock traction technology in the Tumu area, only 15 % of the households use bullocks which plough 14 % of the total cultivated acreage[3]. Contrary to this, in the highly populated Navrongo area, 25 % of the households own bullocks and implements for traction purposes. Here, 39 % of the cultivated acreage is tilled by bullocks.

Irrigated Rice Cultivation

Only farm households in the Navrongo area have the opportunity to grow rice under irrigation because part of the village area belongs to the Tono Irrigation Scheme. Here, irrigated rice farming is supported by extension work, improved input delivery, provision of credit and agronomic research which are provided by a parastatal, the Irrigation Company of the Upper Regions (ICOUR). Extension messages include a complete package of recommendations regarding the use of varieties, agrochemicals and management practices.

In this densely populated area renting of an irrigated plot is the most important opportunity for the farm households to extend the farm size within the vicinity of the compounds. Clearly, variable costs of rice production are substantially higher than those of the traditional crop enterprises. But gross margins of rice by far exceed gross margins of traditional crops (Table 4). The importance of rice for the farm households in this area is underlined by the fact that rice production generated between 45 an 80 % of the income of the rice farmers in 1987/88.

However, despite its high profitability, 35 % of the households do not rent a rice plot. These households still rely on the cultivation of traditional rainfed crops.

Cotton production

Adoption of cotton production has only been observed in the village located in the Tumu District which is characterized by a low population density. Cotton production does not require much cash outlays as cotton growers cultivate the crop under contract. The buying firms provide seed, fertilizer, pesticides, spraying services, and take also care of the haulage of the harvest.

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3 More information is provided in Annex A.

As cotton is a pure cash crop the 'food vs. cash crop' question arises. Interestingly, it was observed that cotton growers allocate the same acreage per consumer to food crops as the non-growers. However, when gross margins per hectare of cotton are compared to gross margins per ha of the traditional crops, cotton is by far the least profitable crop as can be seen from Table 4.

Despite its low profitability 60 % of the households grow cotton on 9 % of the cultivated acreage.

Finally, it has to be concluded that results of simple partial analysis investigating the superiority/inferiority of a certain innovation do not guarantee that farmers will adopt/not adopt the offered technologies. This clearly indicates that other factors which play a decisive role are normally neglected when standard techniques of economic assessment are employed.

TABLE 4: GROSS MARGINS PER HECTARE AND PER FAMILY MANDAY OF THE MAIN CROP ENTERPRISES1) (COEFFICIENT OF VARIATION IN PARENTHESES), 1987/88.

	Tumu		Navrongo	
	GM/ha	GM/fam-md.	GM/ha	DB/fam-md.
Compound fields,				
- cereals	-	-	43191	280
.- cereal-legumes	-	-	70637 (62)	391 (106)
.- legumes	-	-	15590 (102)	141 (126)
Bush fields,				
.- cereals	83010 (61)	1481 (66)	35204 (178)	296 (160)
.- cereal-legumes	47111 (31)	698 (58)	33385	284
.- root and tuber	444574 (20)	2390 (63)	-	
.- legumes	62954 (59)	647 (64)	50158 (100)	384 (120)
.- cotton	20140 (75)	141 (66)	-	-
Irrigated fields,				
.- rice, wet season	-	-	120783 (67)	1996(76)
.- rice, dry season	-	-	295996 (57)	4553(84)
.- vegetables, dry season		-	283802	426

1) Weighted averages.

Determinants of adoption

In order to get an idea about the variables which may also explain adoption behavior, adopter and non-adopter households were compared for differences in household characteristics. Table 5 summarizes the results of multiple regression analysis on the basis of Tobit- and Probit models[4]. Only variables which have a significant impact on the dependent variable are listed. It can be seen that explanatory variables vary in accordance to the innovation under investigation.

4 When the dependent variable is a (0,1)-variable (non-adoption=0, adoption=1) or a truncated variable (there are no negative fertilizer rates) Probit and Tobit models are the adequate regression models.

Variables showing a significant impact on the amount of fertilizer a household applied included the educational level, the share of compound farm of total cultivated area, the assets per consumer and the area under irrigation.

Adoption of bullocks and the respective equipment is influenced by the assets held per consumer, and whether two male persons older than 10 years are available in order to lead the bullocks.

The acreage under irrigated rice is negatively correlated with the health condition of the household head and positively related to the number of persons which have attended formal school for more than 4 years.

Furthermore cotton production depends significantly on the number of children belonging to the farm-household.

TABLE 5: SIGNIFICANT INTRA-HOUSEHOLD DETERMINANTS OF THE ADOPTION OF AGRICULTURAL INNOVATIONS

Use of Mineral Fertilizers	
- Educational level (No. of household members with > 4 yrs. schooling)	+
- Percentage compound farm	-
- Assets per consumer	+
- Total amount irrigation levy	+
Bullock Technology	
- Educational level (No. of household members with > 4 yrs. schooling)	+
- Assets per consumer	+
- > 2 male household members (more than 10 years old)	+
Rice Farming under Irrigation	
- Educational level (No. of household members with > 4 yrs. schooling	+
- Sickness	-
Cotton Production	
- No. of children	+

In the case of fertilizer and bullock traction the available capital per consumer is an important factor determining adoption. In fact, most households reported that they do not have access to credit. This means that actual official rates of interest are not relevant for the majority of households. However, it has to be noted that many farmers have accumulated a substantial stock of wealth by keeping cattle. Farm-households regard livestock as their traditional 'savings and insurance company'. Animals are kept in order to smoothen interannual variations of crop production income which is most likely more susceptible to weather risks than income from livestock production. Therefore these assets are not used for covering variable crop production costs although returns to livestock production are found to be lower than the returns to the selected innovations. As such, the profit foregone has to be regarded as the risk premium farm-households are willing to pay for increased food security.

When credit is made available as in the case of irrigated rice farming assets per consumer do no longer explain adoption. Then a new constraint to adoption seems to be the health status of the farmer. Farmers who are sick reported that they are not willing to take a loan. They fear that they may not be able to carry out the work properly in order to achieve yields which are high enough to cover interest and repayment of the credit. In addition, results indicate that education plays a vital role in explaining adoption of irrigated rice farming and fertilizer use. This seems to be plausible because the aquisition of credit involves a lot of 'paper work'. Illiterate farmers fear that they are cheated as they cannot effectively control what they are going to sign. In this case, transaction costs between literates and illiterates explain the differences in adoption.

Again assets per consumer do not play a role explaining adoption of cotton production probably due to the fact that most of the production costs are directly borne by the buying agencies. Moreover from the viewpoint of the cotton growers, the cultivation of cotton has certain advantages. According to traditional norms cereals are regarded as staple crops which have to be stored until it becomes clear that next seasons harvest will be sufficient to cover family's food requirements. Contrary to the staples, cotton can be sold immediately after the harvest and provides ready cash at the beginning of the dry season. Furthermore, it was reported that the revenue from cotton production goes mainly into men's pockets. The decision to grow cotton therefore depends on whether the household head is able to grow enough food crops in order to fulfill his social responsibilities and to mobilize enough labour for the labour-intensive picking of cotton. As children normally have the lowest opportunity costs of labour among the family members, they can easily be mobilized. Therefore the number of children partially influences the adoption of cotton production.

Conclusions

At first, some issues considering the methodology of technology evaluation will be discussed, followed by policy recommendations and a few proposals for further socio-economic and production oriented research.

The study reveals that simple calculations of profitability which are usually conducted when the feasibility of a new technology is assessed are neither able to explain nor to predict adoption behaviour. It shows that short-term profit maximization is not the only goal farm-households pursue. The major problem to be solved is the incorporation of the adequate opportunity costs of capital and labour. Capital markets are distorted and interest rates provided by official banks necessarily do not reflect actual scarcity of capital at household level. Shadow prices of capital in terms of capital productivity can be estimated by using linear programming methods or production function analysis. With respect to the opportunity costs of labour, age and gender specific differences have to be taken into account.

This in fact also calls for certain methodological adjustments of on-farm experiments. Basically on-farm trials are conducted in order to find out whether improved agricultural systems will fit to farm households labour endowment. But when cash outlays are necessary because improved seeds and other inputs are tested on-farm, it is always argued that farmers are not willing to bear these additional expenses. Therefore all inputs which require additional capital including acquisition and transport costs to the field are usually financed by the research station. This means that although on-farm experiments are carried out under the ecological conditions prevailing on-farm, they partially neglect existing socio-economic circumstances. Therefore capital constraints have to be taken into consideration at least when farmers' subjective perceptions of the performance of on-farm experiments are reviewed. Consequently, when farmers are interviewed they should be confronted explicitly with the additional outlays which the adoption of the tested technology requires.

Again, the results clearly show that farm-households operate not only under various ecological conditions but also under different socio-economic conditions. Therefore when on-farm trials are carried out it should be taken into consideration that the participating farm-households also cover the complete range with regard to the socio-economic status of the households (resource-rich as well as resource-poor farmers).

Policy recommendations include the revision of the credit policy in order to arrive at realistic rates of interest in order to balance supply (savings) and demand (credit) of capital. Moreover, basic formal education and health are important determinants influencing the profitability of new technologies and the access to supporting services. Therefore, basic education and health are playing a key role in order to facilitate growth of agricultural production.

With respect to the irrigation scheme it is found that rice production would still have been profitable in 1987/88 when irrigation levy and cost of tractor services would have been doubled. Therefore the removal of subsidies should be taken seriously into consideration in order to maintain the quality of current services (water delivery, canal maintenance, extension, input supply, research). Moreover, there is still an untapped potential to increase agricultural production within the scheme. For instance, more land could be allocated to those small- scale farmers which do not participate yet. This could be achieved by reducing the plot sizes allocated to the farmers. Then labour intensity per hectare will most likely rise which would e.g. favour the practice of transplanting rice. In addition, there are indications that investments considering the maintenance of soil productivity are very low due to the fact that at present tenure rights of irrigated land are not secure. Land should either be completely privatized or rented to the farmers on the basis of long-term contracts.

Apart from identified problems which can already be addressed by policy measures socioeconomic research is still needed to better understand certain aspects of the traditional farm-household system.

As the traditional social security system seems to restrict capital availability of the farm households it would be interesting to investigate this system more intensively over quite a long period of time. The different mechanisms of inter-household transfers (i.e. gifts, labour obligations, marriages, livestock sales, visiting relatives) and its impact on liquidity should be reviewed in order to identify viable alternative institutional arrangements insuring farm-households against crop failures which are less capital demanding.

Basic research is also needed in the area of determining the riskiness of crop and livestock production. Therefore site-specific time-series data have to be collected.

Finally, a number of technical problems are still to be solved:

- Irrigation: Agronomic measures to reduce the increasing pressure of pests and diseases, e.g. identifying appropriate rotations which enable a more effective weed management,
- development of efficient and safe pest management methods for dry season-gardening,
- fertilizer strategies for mixed cropping at different sites and under suboptimal management conditions,
- quantitative evaluation of possible negative/positive effects of existing farming systems on soil fertility and long-term sustainability.

ANNEX A: RATES OF ADOPTION OF SELECTED INNOVATIONS IN THE TWO VILLAGES, UPPER REGIONS1), 1987/88

	Tumu	Navrongo
Mineral fertilizer		
- Rate of adoption	80 %	70 %
- Area fertilized (in % of cultivated acreage)	44 %	31 %
- Fertilizer rate on fertilized plots (kg N/ha)		
maize	31 (48 %)	-
maize/millet	14 (109 %)	-
cotton	40 (41 %)	-
rice, wet season	-	77 (73 %)2)
rice, dry season	-	91 (72 %)
vegetables	-	171 (282 %)
Bullock traction technology		
- Bullock owner	15 %	25 %
- Bullock hirer	1 %	41 %
- Non-user	74 %	34 %
- Acreage, ploughed	14 %	6 %
ridged	2 %	33 %
Utilization of tractors		
- Owner	2 %	0.5 %
- Households hiring	28 %	22 %
- Acreage, tractor ploughed	2 %	31 %
Irrigated rice		
- HH-head and sons	-	25 % (46 %)3)
- HH-head	-	30 % (31 %)
- Son	-	10 % (19 %)
- Non-adopter	-	35 %
Cotton grower	50 % (9 %)3)	-

1) Acreages are estimated from household data.
2) Coefficient of variation (in %) in parentheses.
3) Figures in parentheses represent the acreage covered by rice and cotton, respectively in terms of percentage of total cultivated farm area.

Annex B: Results of Production Function Analysis (dependent variable: yield per hectare, MJ/ha)1)

	Tumu Bush cer/legum.	Navrongo Compound cer/legum.	Navrongo Cpd/Bush legumes	Navrongo Irrigation rice, dry
Independent variables:				
Soil preparation2)	6113.8 **	- 441.9	- 4351.8	-
Sowing rate (C/ha)	3.2 *	5.4 ***	0.1	0.9
Sowing date (mth)	-	- 7469.2 ***	957.5	-9415.3 **
Organic manure3)	-	197.0 *	-	-
kg N/ha (lin.)	- 261.8 *	-	-	-194.20 ***
kg N/ha (sqrt.)4)	3432.4 ***	-	-	4572.6 ***
Split application	-	-	-	3020.2
Time weeding5)	-8122.1 ****	- 3472.2 *	2235.8	-
No. weedings	-	6122.1 ***	289.4	9584.6 **
Herbicide C/ha	-	-	-	0.3
Labour md/ha (lin.)5)	-21.3	- 7.5	20.5 ***	- 7.2
Location6)	-	-	7039.2 **	-
Constant	22495.6 ****	35431.4 **	- 2809.4	115055.3 *
N	47	34	25	27
R2adj.	0.40	0.31	0.20	0.48
F-value	6.2 ****	3.1 ***	1.8 *	4.1 ****

1) Asterisks indicate the level of significance: * p=0.25 ** p=0.1 *** p=0.05 **** p=0.01
2) Dummy variable (0=hoe, 1=bullock traction)
3) Availability of organic manure in terms of tropical livestock units/ha compound fields
4) Square root
5) without harvest labour
6) Dummy variable (compound=0, bush=1)

Annex C

Annex C: Multiperiod Analysis of Bullock Traction Investment, Non-adopter, SAkai (1987/88)

Year		0	1	2-5	6	7	8
1. Cultivated land	ha	4.05	4.36	4.68	4.68	4.68	4.68
2. Value (crop prod.)	C/ha	88168	88184	88199	81999	88199	88199
3. Var. Costs	C/ha	4664	4665	4666	4666	4666	4666
4. - tractor services	C/ha						
5. - fertilizer costs	C/ha	645	645	646	646	646	646
6. Crop Prod. Income	C/ha	83504	83520	83533	83533	83538	83533
7. Crop Prod. Income	C	338215	364400	390584	390584	390584	390584
8. Livestock Prod. Inc.	C	58020	58020	58020	58020	58020	58020
9. Fixed costs	C	3041	3041	3041	3041	3041	3041
10. Total Farm Income	C	393194	419379	445563	445563	445563	445563
Expenditure Bullock traction							
11. Bullocks	C		50000		50000		
12. Plough	C		18750				
13. Cart	C		43000				
14. Nose, rings, ropes etc	C		1625				
15. Fodder, veterninary costs	C		531	531	531	531	531
16. Maintenance	C		183	183	183	183	183
17. Maintenance (total)	C		798	856	856	856	856
18. Total Expenditure	C		114704	1387	51387	1387	1387
19. Off-farm income	C	2882	2882	2882	2882	2882	2882
20. Salvage value (bullocks)	C				50000		50000
21. Provision of traction services							
22. Add. Income inc. employment							
23. Total household income	C	396076	307556	447059	447059	497059	497059
24. Incremental income			-88520	50982	50982	50982	100982
25. Internal rate of Return (%)		56.48%					
Labour Balance							
26. Wage rate (C/md)		526.4	555.6	583.4	583.4	583.4	583.4
27. Farm Labour (md)							
28. Off-farm traction services							
29. Labour, fodder provision			10.8	10.8	10.8	10.8	10.8
30. Difference, abs. (md)			40.0	67.8	67.8	67.8	67.8
31. Mandays per man-equivalent		142	150	157	157	157	157
32. Difference, relative			6%	11%	11%	11%	11%

Annex D.

Annex D: Multiperiod Analysis of the Bullock Traction Investment, Navrongo (1987/88)

Year		0	1	2-5	6	7-10	11	12-14	15
1. Cultivated land	ha	0.81	0.85	0.88	0.88	0.88	0.88	0.88	0.88
2. Value (crop prod.)	C/ha	72225	71771	71354	71354	71354	71354	71354	71354
3. Var. Costs	C/ha	7861	7630	7419	7419	7419	7419	7419	7419
4. - tractor services	C/ha								
5. - fertilizer costs	C/ha	2398	2292	2196	2196	2196	2196	2196	2196
6. Crop Prod. Income	C/ha	64364	64140	63935	63935	63935	63935	63935	63935
7. Crop Prod. Income	C	52096	54303	56510	56510	56510	56510	56510	56510
8. Livestock Prod. Inc.	C	-495	-495	-495	-495	-495	-495	-495	-495
9. Fixed costs	C	2760	2760	2760	2760	2760	2760	2760	2760
10. Total Farm Income	C	48841	51048	53255	53255	53255	53255	53255	53255
Expenditure Bullock traction									
11. Bullocks	C		50000		50000		50000		
12. Plough	C		14500						
13. Nose rings, ropes etc	C		1625						
14. Fodder, veterninary	C		2373	2373	2373	2373	2373	2373	2373
15. Maintenance cost ha/C			1104	1104	1104	1104	1104	1104	1104
16. Total maintenance costs	C		935	976	976	976	976	976	976
17. Total costs			69433	3349	53349	3349	53349	3349	3349
18. Off-farm income	C	12920	12920	12920	12920	12920	12920	12920	12920
19. Salvage value (bullocks)	C				50000		50000		50000
20. Provision of traction services			2100	2100	2100	2100	2100	2100	2100
21. Add. Income inc. employment			131	849	849	849	849	849	849
22. Total household income	C	61761	-3234	65775	65775	65775	65775	65775	115775
23. Incremental income			-64994	4015	4015	4015	4015	4015	54015
24. Internal rate of Return	(%)	5.00%							
Labour Balance									
25. Wage rate	(C/md)	343.2							
26. Farm Labour	(md)	276.8	274.1	272.0	272.0	272.0	272.0	272.0	272.0
27. Off-farm traction services			2.3	2.3	2.3	2.3	2.3	2.3	2.3
28. Labour, fodder provision									
29. Difference, abs.	(md)		-0.4	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5

Annex E: Determinants of the Adoption of Mineral Fertilizer (Tobit Model; Dependent variable: kg fertilizer/household)

Variable	Coeff.	t-value	E(dEy/dx)	E(Ey*/dx)	E(dFz/dx)	Mean
Educational level	138.58	1.86 **	0.1402	0.0870	0.0532	0.3886
Sickness	-3.8887	-0.01	-0.0007	-0.0004	0.00003	0.0681
Share, compound	-3.8915	-2.37 **	-0.2893	-0.1795	-0.1097	28.545
Assests per consumer	4.5411	1.67 *	0.2667	0.1655	0.1012	22.554
Irrigation levy	0.0163	2.63 ***	0.1590	0.0987	0.0603	3747.6
Constant	187.5	1.95 **				

Pred. y>0	0.83
Obs.y>0	0.84
LRT	25.8 ***
N	44
Ey	320.2
Ey*	384.0

Annex F: Determinants of the Adoption of Bullock Traction (Probit-Model)

	Coeff.	t-value	Elasticity
Educational level	1.47	2.17 **	0.14
Assets per consumer	0.068	2.95 ***	0.64
> 2 male persons (more than 10 years old) 0.85	1.30 *		0.22
Sickness	- 4.44	- 0.01	- 2.0*10-8
Constant	- 2.94	- 3.32 ***	-1.11

Likelihood Ratio Test = 35,4 ***
n = 44
correctly predicted observations: 39 (89 %)

Asterisks indicate significance at following levels: * p=0.1 ** p=0.05 *** p=0.01

Annex G: Determinants of the Adoption of Irrigated Rice Farming, Navrongo
(Tobit Modell, dependent variable: ha irrigated land/household)

Variable	Koeff.	t-Value	E(dEy/dx)	E(Ey*/dx)	E(dFz/dx)	Mean
Educational Level	0.29326	2.66 ***	0.2201	0.0913	0.1288	0.35
No. male man-equivalents	0.02752	0.27	0.0992	0.0412	0.0581	1.6815
Sickness	-0.5784	-1.49 *	-0.1240	-0.0515	-0.0726	0.1
Assets per consumer	-1.0E-6	-0.17	-0.0442	-0.0183	-0.0259	20380
Constant	0.047	0.22				

Pred. y>0	0.59	N	40
Obs.y>0	0.58	Ey	0.274
LRT	12.3 ***	Ey*	0.466

Annex H: Determinants of the Adoption of Cotton Cultivation, Tumu
(Tobit Model, dependent variable: ha cotton/household)

Variable	Koeff.	t-Value	E(dEy/dx)	E(Ey*/dx)	E(dFz/dx)	Mean
Educational level	-0.3862	-1.47	-0.3426	-0.0685	-0.2740	0.30
No. of children	0.15789	2.78 ***	1.5080	0.3016	1.2064	3.26
Sickness	-3.5806	-0,01	-1.710	-0.3420	-1.3680	0.16
Assets per consumer	8.5E-6	1.65	0.5724	0.1145	0.4579	22943
Const.	-0.6521	-2.36 *				

Pred. y>0	0.16	N	43
Obs. y>0	0.37	Ey	0.055
LRT	17 ***	Ey*	0.341

GLIRICIDIA SEPIUM (JACQ) STEUD: A POTENTIAL TREE FOR ALLEY CROPPING IN THE SAVANNA ZONE OF GHANA

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Introduction

Alley cropping is an innovative food production technology by which food crops are grown in alleys formed by hedge rows of trees and shrubs, preferably legumes. The hedge rows are cut back at planting and periodically pruned during cropping to prevent shading and to reduce competition with the associated food crops. The foliage so cut is incorporated directly into the soil or applied to the surface as mulch. The International Livestock Centre for Africa (ILCA) has extended the concept of alley cropping to include livestock by using a portion of the hedge row foliage for animal feed, calling the resultant package alley farming (Sumberg and Okali, 1983).

Alley cropping has significant potential for maintaining soil fertility under continuous cropping (Kang et al., 1985). The inclusion of fast growing trees and shrubs, particularly leguminous species, which are grown in hedgerows and are periodically pruned to provide green manure and mulch to the associated food crops can contribute significantly in: (1) nutrient recycling, (2) nitrogen supply, (3) soil conservation, (4) partial weed suppression, and (5) maintenance of soil productivity. In addition, the trees can also provide fuelwood, staking materials and livestock feed (Kang et al., 1984). Higher maize and cassava yields were obtained when alley cropped than in the control plots (Kang and Duguma, 1985; Kang, B.T., 1988). Ngambeki (1985) also reported large savings in nitrogen fertilizer when maize is alley cropped with Leucaena.

The farming systems of shifting cultivation and related slash-and-burn cultivation are still dominant land use systems in the savanna zone of Ghana. There may not be adequate land in the near future, due to socio-economic factors, to maintain the long fallow that are essential in these farming systems, thus making their primary function of soil fertility restoration less effective. In this regard, the alley cropping technology which retains the basic features of the traditional fallow system, and which integrates the "art and wisdom of traditional farmers" with "the efficiency of current science" would appear to be a good replacement for the bush fallow or slash-and-burn agriculture currently being practiced in the savanna zone of Ghana. The alley cropping concept is currently being evaluated in many parts of the tropics and has shown promise as a possible replacement for the bush fallow system.

To be useful for alley cropping, a tree specie must be easy to establish and quick to regrow after pruning. Gliricidia sepium (Jacq) is a fast growing, nitrogen fixing tree which is used in various parts of the tropics for fodder, fuelwood, living fence posts, soil improvement and plantation shade (Falvey, 1982). It has many characteristics which make it a promising specie for alley cropping. It is estimated that Gliricidia prunnings can contribute about 40 kg N ha^{-1} to a companion maize crop (Kang, B. T., 1988). Gliricidia foliage is very nutritious, containing about 20% crude protein. It is also believed to be free of toxic elements and thus, unlike Luecaena can be fed in high quantities to livestock without adverse effects. It is for this reason that it is being promoted by ILCA as a companion and alternative specie to Leucaena in alley farming. Nevertheless, there has been relatively little research on its establishment and management and no previous evaluation of Gliricidia germplasm in the savanna zone of Ghana has been done.

In 1986, NAES received different provenances of Gliricidia from ILCA to investigate their adaptability to the different ecological zones of Northern Ghana and their possible integration into the existing farming systems. The specific objectives of the work here therefore were:

(1) to evaluate a collection of G. sepium for initial growth, fodder and wood production, and
(2) to select promising accessions for use in alley cropping and intensive feed gardens.

This paper presents and discusses results so far obtained from this investigation.

Materials and methods

The Gliricidia sepium germplasm consisted of eleven accessions collected from Central America (Guatemala, Honduras, Nicaragua, Mexico and Costa Rica) by the Oxford Forestry Institute (OFI) in 1984, and given to ILCA. These accessions have been given ILCA identification numbers - ILG 52 to 72. Two other Gliricidia accessions, "Ibadan Local" (ILG 50) and " Ibadan HYB" (High Yielding Bulk) were also included. Ibadan HYB is a composite line developed from four high yielding Costa Rican accessions while Ibadan Local is Gliricidia harvested from around the Ibadan area.

Seeds were germinated in nursery bags for five weeks and transplanted in the field on 27th June 1986.
There were two establishment lay-outs:

(i) An alley cropping lay-out for evaluation of tree productivity under continuous cutting management, and
(ii) Continuous growth lay-out for observations on flower initiation, flowering, seeding, dry season leaf retention and disease and pest incidence.

Alley Cropping lay-out:

The 13 accessions of Gliricidia were planted in single row plots 4 m apart and 0.5 m within the rows. Each plot was 2.5 m long and contained 6 trees. Three rows of maize were planted 1.0 m apart in the alleys. The lay-out was a randomised complete block design with three replications.

Height measurements were made on all trees at 3 monthly intervals starting 2 months after transplanting (MAT). Records of number of branches per tree at 6 and 12 MAT and the diameter of the main stem at ground level at 6 monthly intervals were also taken. Trees were pruned to 50 cm above ground level for the first time at 12 MAT and subsequently at 3 monthly intervals. Plant material from each row on every cutting occasion was weighed. Two branches were sampled and separated into leaf and wood portions. These portions were weighed before and after oven drying at 105°C for dry matter determination.

Continuous tree growth lay-out

This lay-out involved 4 trees of each accession (2 replications with 2 trees/rep) in continuous growth for 24 months. The experimental design was RCB. Observations were made on flower initiation, flowering, seeding and any incidence of pest and diseases. At the peak of the dry season in February 1987, all accessions were given a rating based on the visual assessment of their foliage retention. The assessment was carried out simultaneously, but independently by two evaluators using a scoring scale of 1-4
(1 = poor; 2 = fair; 3 = good; 4 = very good).

Results and discussion

Primary height growth. The mean height of the various accessions at 2, 5 and 12 MAT are given in Table 1. The three fastest growing accessions were ILG 50, HYB and ILG 70 (in decreasing order). ILG 50 and HYB showed early signs of height growth vigour, being significantly taller than most of the other accessions. The height growth superiority was maintained at 5 MAT although differences were not significant between the various accessions. After this period however, the HYB grew faster and overtook all other accessions.

Stem girth development

The development of the stem of trees may be influenced by the management adopted. Pruning management, for instance, is expected to slow down stem development in favour of new shoot and leaf growth. It is suspected that the ability of trees to maintain some level of growth in the stem while under pruning management influences the survival and continued productivity of the tree.

TABLE 1. HEIGHT GROWTH OF ACCESSIONS AT 2, 5 AND 12 MAT*.

Accessions	Plant height (cm) at:		
	2 MAT	5 MAT	12 MAT
HYB	117.7	209.7	349.0
ILG 50	131.6	194.0	296.6
ILG 56	105.5	193.0	298.3
ILG 62	110.6	180.3	297.3
ILG 64	105.3	163.7	292.0
ILG 65	91.7	148.3	241.6
ILG 66	89.9	159.0	283.6
ILG 68	91.3	147.7	266.0
ILG 69	11.6	180.7	288.3
ILG 70	114.5	185.7	286.0
ILG 71	99.7	162.3	291.0
ILG 72	87.4	161.0	244.3
LSD (P=0.05)	18.3	42.15	29.62
CV %	10.32	14.32	6.11

*** MAT = months after transplanting.**

Table 2 gives the mean diameters of the trees at 12 MAT for the various accessions. Stem diameter (basal) ranged from 2.7 to 3.4 cm with HYB, ILGs 50, 62, 64, 65, 66, 68, 69 and 71 in the top bracket. These were significantly different from ILGs 56, 70 and 72.

TABLE 2. STEM DIAMETER OF ACCESSIONS 12 MAT*

Accessions:	HYB	50	56	62	64	65	66	68	69	70	71	72
Diameter (cm)	3.4	3.36	2.76	2.8	3.2	2.83	3.3	3.03	2.83	2.76	3.16	2.70

LSD (P=0.05) = 0.355 CV % = 6.96

Branching habit

The branching behaviour of the trees is of interest as it influences the type of system in which they could be used. For instance, an accession with vigourous lateral spread may be very productive but unsuitable for alley cropping. Such an accession would however be very suitable for intensive feed gardens. The mean number of branches in the various accessions in primary growth is given in Table 3. Observations on branching behaviour showed that HYB, ILG 64, 69 and 70 combine their height growth vigour with copious branching.

TABLE 3. NUMBER OF BRANCHES IN ACCESSIONS.

Accession	HYB	50	56	62	64	65	66	68	69	70	71	72
No. of branches	8.0	6.7	5.3	5.7	8.0	6.7	6.7	5.7	8.7	8.0	5.3	5.7

LSD (P=0.05) = 2.879 CV (%) = 25.4

Tree productivity

In the primary harvest at 12 MAT, HYB was clearly superior in mulch production as it significantly out-yielded all other accessions. Other high yielding accessions were ILGs 50, 62, 64 and 68 (Table 4). Coppice productivity changed spectacularly following the first cutting (Table 4). In the primary harvest, ILG 69 ranked 10th but rose to 4th, 3rd and 2nd positions in subsequent harvests. ILG 62 exhibited a positive but short lived response to pruning as it ranked 3rd in the primary harvest but reverted to the bottom of the scale in subsequent coppices. The regrowth vigour exhibited by HYB in height growth was reflected in mulch production, as it again consistently out-yielded all other accessions. The next most consistent yielders were ILG 64 and ILG 50. It must be noted that ILG 72 had the least mulch production in all four harvests. The 3rd and 4th harvest figures are much higher than the 2nd harvest. This increase is probably caused by the inception of the rains.

Flower initiation and flowering

Flower initiation in Gliricidia was noticed in December 1986, 7 MAT. The first flower buds were seen in the last week of December 1986 in ILG 72 on all 4 trees (Table 5). At the end of the second week in January 1987, all flower buds on this accession were opened. By the end of January 1987, three other accessions ILGs 69, 57, and HYB had all 4 trees in buds, at which time ILG 72 had initiated podding (Table 5). Other accessions which flowered by mid February were ILGs 50 and 64 (Table 5). It is interesting to note that ILG 72 which had the least biomass production was the first to flower and even form mature pods. Generally, it could be deduced that not all the Gliricidia accessions could flower in this zone.

TABLE 4. FRESH MULCH YIELDS (KG/PLOT) FROM 4 HARVESTS OF G. SEPIUM

Accessions	HARVESTS			
	June '87 Harv.1	April '88 Harv. 2	July '88 Harv. 3	Oct. '88 Harv.4
ILG 50	18.23	7.63	14.40	15.41
56	11.30	7.80	15.46	11.86
62	15.88	5.79	13.40	12.56
64	13.58	6.79	15.86	15.63
65	11.09	5.44	12.99	10.29
66	11.46	5.79	15.04	14.87
68	12.13	5.15	12.24	12.12
69	10.07	7.47	16.79	16.01
70	12.11	6.73	14.36	13.98
71	8.56	5.81	19.31	10.28
72	6.34	4.01	10.42	8.13
HYB	22.90	8.02	19.43	18.03
LSD (5%)	5.58	-	5.19	4.07
CV (%)	26.56	-	20.27	18.32

TABLE 5. DATES OF FIRST FLOWER BUDS OBSERVED IN VARIOUS ACCESSIONS.

Accessions	Dec. '86	Jan. 1987				Feb. 1988	
	W4[a]	W1	W2	W3	W4	W1	W2
ILG 50							
" 56							***
" 62							
" 64							
" 65							**
" 66							
" 67							
" 68							
" 69							
" 70						****	
" 71							
" 72	****						
" 57							
HYB						****	
						****	
Total	4					12	5

* = No. of trees observed with flower buds.
a = W = Week.

Assessment of dry season leaf retention, pest and diseases

An assessment of dry season leaf retention showed ILG 50 to be notably superior while seven other accessions including HYB, ILGs 66, 67, 68, 62, 54, and 56 were found to have good (average) dry season leaf retention abilities. Six other accessions were rated as having below average dry season leaf retention. There was no noticeable incidence of pest and diseases.

Conclusion

On the basis of tree productivity, height and stem growth, HYB, ILGs 50, 69 64, 56 and 70 could be selected as the most promising accessions for this zone for alley farming. The least productive accessions include ILGs 72, 68, 62 and 71.

A number of accessions stand out very clearly as having potential for flowering in the zone. ILGs 50, 72, 69, 64, 57 and HYB appear to be the most vigourous and early flowering accessions. These are potentially the best seed producers.

References

Falvey, J.L. 1982. Gliricidia sepium - A review. The International Tree Crops J. 2: 1-14.

Kang, B.T. and B. Duguma. 1985. Nitrogen management in alley cropping systems. In: B.T. Kang and J. van det Heide (eds), Nitrogen in farming systems in the humid and sub-humid tropics. Haren, Netherlands: Institute of Soil Fertility.

Kang, B.T., H. Grimme and T.L. Lawson. 1985. Alley cropping sequentially cropped maize and cowpea with Leucaena on a sandy soil in southern Nigeria. Plant and Soil 85: 267-276

Kang, B.T. 1988. Nitrogen cycling in multiple cropping systems. In: Advances in Nitrogen cycling in Agricultural Ecosystems, J.R. Wilson (ed): 333-348. CAB Int., Wallingford, England.

Ngambeki, D.S. 1985. Economic evaluation of alley cropping Leucaena with maize - maize and maize - cowpea in Southern Nigeria. Agric. Systems 17: 243 -358

Sumberg, J.E. and Okali, C. 1983. Linking crop and animal production. A pilot development programme for small-holders in south west Nigeria. Rural Development in Nigeria - 1.

Discussion

F.N.A. ODOI

COMMENT: Some work done assessing the productivity of some exotic spp. of Gliricidia sepium (source ILCA) and a "local wild" variety in the Cape Coast area showed that although the local variety was low yielding it flowered and seeded by the 7-9th month, while none of the exotic high yielding varieties did by 18 months.

D.K. ACQUAYE

(1) Since contribution of N is one of the desirable attributes for selection, did you determine the N contribution of the accessions?

(2) There are many local species of Gliricidia. Why is it that you did not include a local species in your work?

J.B. NAAB

(1) An analysis of soil samples showed that there was no significant increase in total nitrogen. An analysis was also made of the biomass for total N, and P.

(2) I was not aware of the existence of local Gliricidia at the start of the experiment.

SESSION 2

CHAIRMAN: PROF. K.A. HAIZEL, UNIVERSITY OF CAPE COAST.

PROGRESS IN SORGHUM AND PEARL MILLET IMPROVEMENT AND PRODUCTION IN GHANA

S.S. Buah and W. Froelich

(Nyankpala Agric Experiment Station)

1. Sorghum production

1.1 Introduction

Sorghum (Sorghum bicolor (L) Moench) commonly called "guinea corn" in West Africa is an important and widely cultivated cereal crop in the northern savanna zone of Ghana which includes the two Upper Regions and the Northern Region. Rainfall which is monomodal lasts from April to September but may extend to October in the Northern Region. In terms of area cultivated to cereals, sorghum is only exceeded by maize in the Northern Region and millet in the Upper Regions. However, the production of the crop has stretched further south. This could be attributed to the versatility of the crop both in utility and environmental requirements for growth. It is grown to a limited extent in Brong-Ahafo Region, Volta Region, and the Accra plains. Sorghum is grown both on ridges and on flat. Traditionally, the crop is grown as rainfed crop and in association with other cereals and legumes at low densities. However, sole cropping (about 6%) is also practiced in the northwestern parts of the country. All sorghum grain is produced for human consumption, mainly as porridge (koko), tuo zaafi (T.Z.) and the red grain types are also mainly used for making local beer known as pito. The leaves are used as animal feed, while the stalks are used for making baskets, hats, and barns. They also provide fuel and shelter. In addition to these traditional uses, the industrial use of the crop for brewing lager beer and other products has to be taken into consideration for the future.

There are many constraints related to sorghum production in Ghana, ranging from agronomic practices, diseases and pests problems, to lack of industrial use of the crop. In view of the potential use of the sorghum grain for industrial purposes, large scale production would require the use of efficient improved technology. This would include the use of certified seed of improved varieties, adequate crop protection measures and efficient crop management practices.

1.2. Production Figures

Estimates for the production of sorghum in Ghana and many other countries are necessarily approximate, and most of them combine data for both sorghum and millet. Tables 1 and 2 give average areas and yields for five years, respectively. There seems to be an increase in the area under sorghum and millet in the last two years whilst production is on the decline.

TABLE 1: AREA UNDER SORGHUM AND MILLET IN GHANA (IN 1,000 HA) FROM 1983 TO 1987 (COMPARED WITH AREA UNDER MAIZE).

	1983	1984	1985	1986	1987
Maize	400	720	405	543	544
Guinea Corn and Millet	220*	487	477	497	497

TABLE 2: PRODUCTION OF SORGHUM AND MILLET IN GHANA (IN 1,000 T) FROM 1983 TO 1987 (COMPARED WITH MAIZE PRODUCTION).

	1983	1984	1985	1986	1987
Maize	172	574	395	576	457
Guinea Corn and Millet	56*	315	305	798	798

*** Guinea Corn only.**
Source: Ghana in Figures, 1987. Compiled by the Statistical Service of Ghana

When sorghum is grown in combination with two or three crops, the plant population is usually about 12,000-15,000 plants per hectare, with 2-3 plants per hill (Schipprack and Quarshie, 1984). A number of cropping mixtures have been identified but the adoption of a particular crop mixture varies between regions and districts. Sorghum is usually intercropped with other cereals like maize, early millet, or late millet or with legumes like cowpea, groundnuts or soybeans. Sorghum is normally planted by the end of May in northern and early June in the southern parts of the northern savanna zone, about three weeks after maize has been planted. Generally, farmers would cultivate long duration varieties only when the rains are early, whilst the short duration varieties are cultivated when the rains start late. This reflects their aversion to risk which is of major concern to them. Fertilizer is normally not applied to sorghum but thinning and transplanting may be done where necessary. No specific crop rotation is followed but the common practice is that yam is grown the first year after fallow, then a crop mixture which normally includes sorghum is planted. Maize is however, replaced by sorghum or late millet in the mixture as soil fertility declines.

The yield of sorghum in the traditional system is quite low. Generally, yields range from 800-1000/ha (Obimpeh, 1989). The low yields could be attributed to the cultivation of local photoperiod sensitive cultivars, with inherent low grain yield levels, lack of fertilizer use, low planting densities in the traditional mix cropping system, and poor management practices in general. Most of the traditional cultivars in Ghana belong to the Guinea race also known as Belko type. However, two other races are also cultivated. The Caudatum race locally called Gambaga type is grown in the Upper Regions whereas the Bicolor race, known as Nunaba type, is commonly found in the north western parts of Upper West Region.

1.4 Constraints to Sorghum Production

The principal constraints to sorghum production are different for the various maturity groups of sorghum and also vary from one area to another. Broadly, these are:

(a) lack of suitable improved, high yielding cultivars;

(b) biological factors such as diseases, insects, weeds, and bird damages;

(c) physical factors such as degraded infertile soils and erratic rainfall patterns;

(d) incomplete collection and documentation of local germplasm.

When the early materials are planted early, moulds caused by Curvularia and Fusarium spp. are a serious problem. The grain produced in such a situation is often of unacceptable quality. When planted too late in order to avoid the crop maturing during periods of highest rainfall, pest attacks, especially shootfly (Atherigona soccata), headbugs and cotton stainers become a problem. The introductions are more susceptible to grain mould than the local types. This is due to their erect and compact heads (with soft endosperm grain) which easily trap rain water, dew, and insects. Farmers in the sorghum growing areas of Ghana prefer the local genotypes with loose and drooping panicles and also hard and vitreous grains. However, complete crop failure is possible with the traditional cultivars which are often late and tall (5 m and above) if the rains stop early. Thus, recurrent droughts of recent years have influenced farmers' choice for early maturing varieties. The onset of the drought cannot be determined. The emphasis here should therefore be on drought tolerant varieties having the desired agronomic traits.

Sorghum midge (Contarinia sorghicola) infestation could lead to considerable yield reduction. Stem borers can also reduce grain yield of sorghum.

Bird damage is more severe on those varieties which mature earlier than the surrounding fields, and also those with erect and compact panicles with white and often sweet grains.

Witchweed (Striga hermonthica), a parasitic weed, is a serious problem for all sorghum varieties, particularly in the more densely populated areas of the Upper East Region.

Sorghum is also attacked by a wide range of stem, leaf, and panicle diseases such as anthracnose (Colletotrichum graminicola), various leaf spots, and smuts. These often adversely affect yield by reducing the photosynthetically active areas of the plant.

Degraded infertile soils and erratic rainfall in the zone constitute the major physical constraints.

2. Sorghum improvement

2.1 Objectives

The objectives of the improvement programme are the identification and development of:

(a) early maturing high-yielding varieties (less than 80 days to 50% flowering, DFF) with acceptable grain quality and resistances to the major pests and diseases;

(b) intermediate materials (80-95 DFF) with good yield potential in both grain and stalk and acceptable grain quality (hard and vitreous endosperm)

(c) full season varieties (100-120 DFF) with a higher yield potential than the local cultivars and with reduced height. Emphasis is on resistance/tolerance to Striga and midge.

2.2 Programme outline

Basically, the sorghum improvement programme covers three regions or two ecological zones as determined by total annual rainfall. These are the Guinea savanna which has an annual rainfall of 1000-1400 mm and the Sudan savanna which also has an annual rainfall of 900-1100 mm. However, the improvement programme coordinating centre is at Nyankpala in the northern Guinea Savanna Zone. The approaches adopted in the programme are mentioned below.

2.2.1

Screening and testing of introduced materials to identify suitable varieties based on diseases and pests resistances, maturity period, height, panicle type, and grain yield. In this respect, we cooperate closely with ICRISAT Centre in India and

its West African programmes in conducting yield trials and also testing varieties for their resistances/tolerances to the major pests, foliar diseases, and Striga.

Selected entries are then evaluated in station variety trials at Nyankpala and Damongo (Northern Region), Wa and Tumu (Upper West Region), and Zuarungu and Manga (Upper East Region) for at least two years before the promising varieties are planted in multilocational trials. The best varieties selected from these trials are included in the on-farm experimentation programme in which they are tested at different management levels and in different crop mixtures.

2.2.2 Screening and improvement of local cultivars

Selection is carried out within the local cultivars for uniform and superior strains. Desirable heads are visually selected from farmers and experimental fields and planted in observation rows on the station. Further single-head selection and head-to-row planting is done until there is uniformity. These are included in the station variety trials. There is however, the likelihood of repetition of genotypes since one cultivar could have different names in different villages.

2.2.3 Hybridization and selection programme

The well adapted local cultivars have inherent low-yielding ability whereas the introduced improved varieties are poorly adapted even though they have higher and stable yield across normal and abnormal years. Emphasis is therefore placed on improving local cultivars through hybridization and selection.

2.3 Some results of the improvement programme

A crossing programme involving early and late materials belonging to the Guinea race was initiated in 1985 and 1986. However, the best selections in the F5 do not meet the preference of both farmers and consumers for loose and drooping heads with good grain quality. Doggett (1988) stated that segregates from the F2 of crosses with the Guinea race always have very poor heads if the grains are white and very corneous. However, the F1 seed of some crosses from last season will be planted in the 1990 season. These crosses involved locally adapted genotypes like Kadaga and introduced varieties like Framida with high grain yield potential. The female components were chosen based on their earliness and short stature. Another crossing programme would be initiated this season to:

a. Transfer midge resistance from varieties like ICSV 197 IN, Banju, or Pogkuori latuori to Kokuahibua, a well adapted but susceptible local cultivar which is commonly cultivated in the northern Guinea savanna. The last two varieties belong to the bicolor race of sorghum.

b. Improve the seed quality of Naga White (a variety that originated from Ghana) which has a high grain yield potential but has poor nutritional quality. In order to achieve this, Naga White would be crossed with a hard grain type of sorghum collected from Nobere in Burkina Faso.

TABLE 3: WEST AFRICAN SORGHUM VARIETY ADAPTATION TRIAL - EARLY DURATION (WASVAT-1988) CONDUCTED AT NYANKPALA

No.	Entry	Days to 50% flowering	Plant height (cm)	Grain yield kg/ha
1.	Naga White	67	210	2702
2.	S-35	74	219	3028
3.	Mali Sor 84-5	69	213	2360
4.	CE 180-33	63	160	1930
5.	CE 194-19	65	185	1408
6.	ICSV 401 IN	73	185	1827
7.	ICSV 210 IN	78	225	2782
8.	ICSV 111 IN	74	232	2912
9.	ICSV 230 IN	78	172	927
10.	ICSV 247 IN	70	200	1809
11.	ICSV 1082 BF	68	204	1685
12.	ICSV 1083	81	244	1430
13.	ICSV 1084	83	229	1610
14.	ICSV 1085	83	239	1213
15.	ICSV 1086	82	220	1534
16.	ICSV 1087	73	171	2587
17.	ICSV 1078	72	206	2917
18.	ICSV 1054	75	180	2742
19.	IRAT 204	68	143	1578
20.	Naga White (control)	75	194	1773
Mean		73	201	2038
S.E.		3.2	7.7	237.4
C.V%		7.6	6.6	20.2
LSD (0.05)		9.2	21.9	679.8

Planting Date: 04-07-88

Despite the poor seed quality of Naga White, it has been found to be performing well in the West Africa Sorghum Variety Adaptation Trial (WASVAT)- early duration, and in various station trials at Nyankpala. In the 1987 WASVAT- early duration, Naga White gave the highest mean grain yield of 2800 kg/ha across seven locations (ICRISAT Annual Report, 1987), However, in 1988 and 1989, it was outyielded by some early varieties including ICSV 111 IN tested in both WASVAT and station trials at Nyankpala. ICSV 111 IN, a promising variety ranked third and first with mean grain yields of 2912 and 1552 kg/ha out of twenty entries in each case in the 1988 and 1989 WASVAT trials, respectively, conducted at Nyankpala (Tables 3 and 4).

TABLE 4: WEST AFRICAN SORGHUM VARIETY ADAPTATION TRIAL-SHORT CYCLE (WASVAT-1989) CONDUCTED AT NYANKPALA.

No.	Entry	Days to 50% flowering	Plant height (cm)	Grain yield kg/ha
1.	CS 54	68	181	1195
2.	CS 61	68	178	1343
3.	CE 151-382	64	171	1137
4.	CF 196-7-2-1	63	165	1069
5.	Nabana Beida	79	207	658
6.	Lekwer Bedha	80	211	562
7.	ICSV 242 IN	82	181	682
8.	ICSV 258 IN	82	199	690
9.	ICSV 401 IN	67	167	1013
10.	ICSV 1079 BF	75	184	1176
11.	ICSV 1170 BF	69	183	944
12.	ICSV 1177 BF	76	200	488
13.	ICSV 1172 BF	82	200	488
14.	ICSV 1174 BF	75	195	801
15.	ICSV 1125 BF	80	197	774
16.	ICSV 1175 BF	81	187	683
17.	ICSV 1176 BF	73	148	876
18.	Naga White	63	166	856
19.	ICSV 111 IN	66	182	1552
20.	Naga White (Control)	65	178	1039
Mean		73	183	926
S.E		1.1	4.9	15.1
CV%		1.8	8.6	26.2
LSD (0.05)		2.9	44.8	536.5

Planting Date: 18-07-89.

Another promising early variety ICSV 16-5 BF ranked first at two locations; Nyankpala and Manga, in the 1987 station variety trials for early varieties. It also gave the highest mean grain yield of 1349 kg/ha across these two locations. It was followed by ICSV 111 IN (Table 5). In the same trial in 1989, ICSV 16-5 BF again ranked first with a mean grain yield of 1817 kg/ha (Table 6).

The data, however, is not yet sufficient to conclude that some early varieties tested here have higher yield potential than Naga White. This is because reports from ICRISAT West African Programmes have shown that Naga White is still superior in terms of grain yield to most early varieties and has even been used in the national programmes of most West African countries. However, bird and insect damage coupled with poor

seedling establishment in some varieties, especially the introductions, adversely affected the experiments. Most of the introductions are quite early and therefore mature in wet weather, thus posing a host of grain quality problems which subsequently affect seedling establishment.

The introduced variety Framida is also quite promising. The dark red type was originally cultivated widely in the Upper West Region where the Sasakawa Global 2000 Programme supported farmers with complete packages. However, most farmers now prefer white grain Framida for food. The normal red grain type which is found to be tolerant to Striga is however used for brewing the local beer known as pito. Moreover, results obtained in September,

TABLE 5: MEAN GRAIN YIELD OF EARLY DURATION CULTIVARS IN THE STATION VARIETY TRIAL 1-1987 CONDUCTED AT TWO LOCATIONS.

		Grain yield (kg/ha).		
No	Entry	Nyankpala	Manga	Mean
1.	ICSV 1054 HV	623	306	464
2.	ICSV 16-5 HV	1968	730	1349
3.	ICSV 1065 HV	971	285	628
4.	IRAT 203	107	296	201
5.	Naga White	1299	363	831
6.	ICSV 16 HV	1449	427	938
7.	FRAMIDA	1205	484	844
8.	ICSV 111 IN	1392	558	975
9.	ICSV 25 HV	1407	411	909
10.	Kadaga	1279	318	798
11.	KSV 13	975	530	752
12.	ICSV 1031 BF	602	430	516
13.	Naga	1331	213	772
14.	Nangbilla	423	432	427
15.	ICSV 2 BF	761	248	504
16.	Kulin-Nua	1065	346	705
Mean		1054	398	726
S.E		119	86.8	
CV%		22.7	43.6	
LSD (0.05)		341	247	

Planting Date: 09-07-87.

TABLE 6: PERFORMANCE OF SORGHUM STATION VARIETY TRIAL EARLY DURATION 1989 CONDUCTED AT NYANKPALA.

No.	Entry	Days to 50% flowering	Plant height (cm)	Grain yield (kg/ha)
1	Naga White	64	174	1262
2.	Kadaga	65	259	1714
3.	S-35	73	177	879
4.	Mali Sor 84-5	75	189	991
5.	ICSV 111 IN	72	170	1045
6.	ICSV 1087 BF	81	154	770
7.	ICSV 1078 BF	76	192	1200
8.	ICSV 16-5 BF	66	203	1817
9.	84 S 92	77	203	949
10.	84 S 105-2	74	198	1024
Mean		73	192	1165
S.E		1.9	3.2	31.5
CV %		3.8	6.3	15.7
LSD (0.05)		4.0	17.7	532.1

Planting Date: 18-07-89.

1989, from Germany have shown that Framida is suitable for brewing lager beer in spite of its red grain colour. Thus, more seed samples of a number of sorghum genotypes have been sent to European and Ghanaian institutions to test for their malting and brewing qualities. This is in line with the Ghana Government's plans to substitute or supplement imported barley malt with locally produced sorghum malt for brewing lager beer.

During the last two to three seasons, segregations in grain colour have been observed in Framida on both farmers and experimental fields. The progenies of these types often closely resembled Framida in many morphological characters. A number of individual panicles have been selected and these would be assessed for their head-to-row performance during the 1990 crop season at Nyankpala. Selection will continue until uniformity is achieved when bulking would be done. It is also envisaged that these natural types will be tested for their adaptation, yield potential, and Striga tolerance in comparison with the normal dark red type.

NSV-1, a medium maturing tall variety with a loose and drooping panicle is quite promising. It has stable yields over the years even under poor fertility conditions. Even though it is not the highest yielding variety amongst the medium maturing varieties tested at Nyankpala, it has good seed quality as compared to the high yielding introductions. This is evident from the germination percentage figures in Table 7. Another promising medium maturing variety NSV-2 is yet to be tested multilocationally. It is also as tall as NSV-1 and has loose and drooping panicles, and a different grain colour.

The improvement programme concentrates on the early to medium maturing varieties. This is because the tall and late cultivars produce straw at the expense of grain and improvement

in these photoperiod sensitive types is also quite difficult. However, Local 29, a tall and late cultivar, is found to be relatively less susceptible to midge and it also possesses good grain quality.

A number of recommendations have been made for the cultivation of sorghum. The programme has identified a number of promising varieties belonging to different maturity groups and these have been recommended to farmers. The most important characteristics of these varieties are presented in Table 8.

A number of medium tall varieties which are superior to the late and tall varieties in terms of grain yield but still provide good stalks for fuel, fencing, and roofing have been identified. These include NSV-1, NSV-2, Kokuahibua, and Belko. In their rotation trials at Nyankpala, Schmidt and Frey (1988) have reported that sorghum planted after maize or sorghum planted after sorghum proved to be a bad succeeding crop. Thus, it should be planted after a legume. Farm yard manure should however be added to the crop especially in areas where it is not possible to leave the land fallow.

TABLE 7: MEAN PERCENT GERMINATION OF THE 4 BEST SORGHUM VARIETIES OUT OF 20 AND THEIR GRAIN YIELD IN THE WASVAT-MEDIUM CYCLE 1989 CONDUCTED AT NYANKPALA.

No.	Entry	Grain yield (kg/ha)	Mean percent germination
1.	F2-20	1942	31
2.	IS 23526	1772	40
3.	ICSV 1089 BF	1485	34
4.	CS 85	1472	29
5.	NSV-1	1079	85
6.	Blanc de Karimama	744	80
Mean		1126	37
S.E		23.5	12.4
CV %		40.7	21.4
LSD (0.05)		1014.6	13.1

NSV-1 and Blanc de Karimama belong to the Guinea race of sorghum.

At present recommendations for planting distances are for sole crop only. For early varieties, the planting distance should be 0.75 X 0.20 m, medium maturing varieties 0.75 X 0.25 m, and 0.75 X 0.30 m for late varieties. These give plant populations of 66600, 53300, and 44400 plants per hectare, respectively. Plants should be thinned to one plant per stand (preferable not later than 3 weeks after planting).

TABLE 8: RECOMMENDED SORGHUM VARIETIES AND THEIR CHARACTERISTICS

Variety	Maturity	DFF	Plant height (cm)	Grain yield potential (t/ha)	Grain colour
Naga White	early	65	200	5	white
Framida	early	75	250	4	dark red
NSV-1	medium	90	400	3	white
Local 29	late	130	500	2	white

DFF = Days to 50% flowering.

A good response to small fertilizer rates has been obtained even with the local cultivars. Thus, the recommended dosage is 40:30 kg/ha as N and P_2O_5. The phosphorus source should be applied at planting or broadcast before planting. Nitrogen is split and applied 2 weeks and 5-6 weeks after planting.

In the Northern Region, the late materials should be planted in the first week of June whilst the early types are planted in the first week of July. It is however appropriate to plant the medium materials early (mid to end of May) in the Upper Regions and the early materials should be planted mid to end of June.

2.4 Future programmes

The programme will continue as outlined with emphasis on the hybridization programme involving local germplasm and introductions and also a reduction in selection of local varieties mostly belonging to the Guinea race as expected genetic gains are limited. Work would be concentrated on the early and medium maturing sorghum. Efforts will also be directed towards the development and identification of genotypes with high grain yield potential and also with good brewing qualities. In this respect a closer cooperation with West African Sorghum Improvement Programme (WASIP) - Kano and IAR/ABU - Samaru - in Nigeria is envisaged since there are some promising varieties in these programmes.

3. Pearl millet improvement

In the northern savanna zone of Ghana, both early and late pearl millets (Pennisetum glaucum) are cultivated, but the area cropped to late millet is larger. However, the early pearl millet is widely cultivated in the Upper East Region where it tends to assume importance due to the fact that it is an essential staple food crop which helps to bridge the hunger gap for farm households in that area.

The improvement work on this crop is concentrated at Manga near Bawku (U.E.R) where basically, screening of introductions particularly, for their resistances to downy mildew (Sclerospora graminicola), smut, and ergot is done. Earliness in yield trials is a highly desired character.

The general objective of the programme is to identify and develop high yielding early and medium maturing pearl millet varieties with acceptable grain quality and resistance to downy mildew. The programme outline is similar to that of early to medium maturing sorghum and the constraints are also similar.

Results obtained from this programme so far have not been very encouraging. However, a crossing programme involving the well adapted local genotype Manga Nara and an introduction from Northern Nigeria, Ex-Bornu, which is found to be resistant to downy mildew was initiated last season. Manga Nara is however, highly susceptible to the disease but much more earlier than Ex-Bornu. The objective therefore is to incorporate downy mildew resistance from Ex-Bornu into Manga Nara and simultaneously maintain earliness and adaptiveness.

Further population improvement will be carried out on Manga Nara and Ex-Bornu. In future, the programme will concentrate on hybridization and selection of superior cultivars suitable for Ghana. The programme will also cooperate with ICRISAT Sahelian Centre (ISC) in Niamey, Niger, and Lake Chad Research Institute at Maiduguri, Nigeria in the field of introducing and testing new varieties.

Conclusion

Experience from the past three seasons have shown that the introductions are not of direct benefit to the farmer hence efforts would have to be made to increase the grain yield of the local sorghum cultivars through hybridization. The local cultivars have good grain quality and are also well adapted. A number of tall medium maturing sorghum varieties with good grain yield could substitute the tall and late varieties which have low harvest index. However, the collection and evaluation of local germplasm of the Guinea race in the northern savanna zone and adjoining areas has to be intensified.

Most of the introduced pearl millet varieties are also less adapted to our agroclimatic conditions but may be useful as materials for breeding purposes.

References

Doggett H. (1988). Sorghum. 2nd ed. Tropical Agricultural Series. Longman Scientific and Technical/Development Research Centre, Canada.

Obimpeh, S.G. (1989) The development Strategy in Agriculture for Ghana. Paper presented at the Global 2000 Workshop "Feeding the Future - Agricultural Technology Development Strategies for Sub-Saharan Africa". August 1-3, 1989, Accra, Ghana.

Schipprack, W., and Mercer-Quarshie, H. (1984) Sorghum Production and Improvement in Ghana. Paper presented at the Regional Workshop on Sorghum Improvement in West Africa, November, 27-30, 1984, Oaugadougou/Burkina Faso.

Schmidt, G. and Frey, E. (1989) Crop Rotation Effects in Savanna Soil at the Nyankpala Agricultural Experiment Station. Nyankpala Agricultural Research Report (4) 1988. 37 pp.

Discussion

B.A. ALHASSAN

Could the speaker give advantages for thinning sorghum to 1 stand per hill?

S.S. BUAH

Recommended spacings are for sole cropping. To obtain the desired plant population one must have one plant per hill. Having more than one could lead to competition among plants for essential soil nutrients and perhaps shading of lower leaves.

D. BAGBARA

COMMENT: Pay more attention to the agronomy of sorghum than introductions from other countries. Examine cause of lower leaves of sorghum dying before reproductive phase.

S.S. BUAH

Ref. agronomic problem

P.K. KWAKYE

COMMENT: It was noticed K fertilizer was excluded from your fertilization programme. Evidence shows K status drastically reduces with continuous cropping and millet and sorghum respond to K fertilization. You may consider inclusion of K fertilizer in your future programme.

S.S. BUAH

Well taken. Is to be included in fertilization of experiments at Manga.

E. DERY

Would you comment on the lodging nature of ICSV 5 and ICSV 111?

S.S. BUAH

We have not experienced this problem at Nyankpala and also our cooperator in Wa (Mr. Fawzy) has told us that he has not experienced that problem.

S.A. GUMAH

Has the breweries made advances or have you supplied some varieties to them to try which variety will suit their purpose?

S.S. BUAH

Yes, we have contacted Achimota Brewery Company Ltd. (ABC) and they have collected some samples for analyses. We have also given a number of sorghum genotypes to European and Ghanaian institutions to test for their malting and brewing qualities.

J.A. ADOGOBA

What is being done to improve conditions that would help grow early millet for the benefit of people in the Upper East Region staying in the Northern Region?

S.S. BUAH

Early millet is well adapted to the agroclimatic conditions of the Upper Regions. High rainfall in the N/R would pose a number of grain quality problems and also insect infestation problem could lead to complete crop failure (especially cotton stainers) or bad quality seed could be formed.

W. FROELICH, COMMENT: Improvement of (early) pearl millet is also made difficult by poor soil conditions which are frequent in Upper East and Upper West Regions.

Regarding the use of sorghum for brewing lager beer, contacts have been established with European institutes linked to breweries, and Ghanaian breweries (ABC)

RECURRENT SELECTION FOR RESPONSE TO NITROGEN FERTILIZER IN MAIZE

Peter Y.K. Sallah

(Nyankpala Agricultural Experiment Station)

Abstract

Improved maize (Zea mays L.) cultivars that require low rates of nitrogen (N) fertilization to produce high grain yields would be highly desirable for areas practising low input agriculture. One hundred randomly chosen full-sib families from Ejura 7843, a Tuxpeno-related maize population, were evaluated at 40 (low) and 160 (high) kg N ha^{-1} applied as ammonium sulphate and under 50,000 plants ha^{-1} density. Each N level was considered a separate experiment planted adjacent to each other for two years. The objective of the study was to estimate the effectiveness of recurrent selection for improved agronomic performance in the population under the low and high levels of applied N. Genotype and genotype x environment interaction were important sources of variation in grain yield, grain moisture, mid-silk, and plant height at both low and high N. Mean grain yield of the families at high N was approximately 9% higher than yield at low N. Mean days to mid-silk, grain moisture, plant height, ears per plant, and ear acceptability rating were similar for both N regimes. Estimates of heritability and expected genetic gain showed that full-sib family selection for increased grain yield and selection for reduced days to mid-silk, grain moisture and plant height would be effective at both low and high N. However, selection for response to low N environment may be more appropriate for areas practicing low input agriculture.

Introduction

Nitrogen (N) is an important nutrient which directly influences the growth and productivity of maize. Nitrogen is limiting in most soils where maize is grown, and supplemental N is often applied to increase grain yield. Increased N supply may result in increased harvest index (Viets, 1965), average ear height, weight of the second ear in two-eared plants, and, in prolific hybrids, the number of ears per plant (Krantz and Chandler, 1954).

Variation in N utilization among maize genotypes has been reported by many workers including Harvey (1939), Beauchamp et al (1976), Chevalier and Schrader (1977), and Pollmer et al (1979); and N utilization in maize is under polygenic control (Harvey, 1939; Pollmer et al 1979). Genotypic variation for N utilization has permitted selection for this trait in maize (Muruli and Paulsen, 1981; Moll et al 1987).

Maize producers in developing countries generally rely on soil residual N. Average maize yields are low, partly because of this practice, and yield increases from N fertilization could be large. Nitrogen fertilization is being vigorously promoted in many countries to boost maize production. However, problems with N fertilizer availability, high costs, and the potential danger of contaminating water resources are of major concern. One viable approach to limit these problems may be to develop maize cultivars that utilize N fertilizer more efficiently and require relatively low levels of N fertilization to produce acceptable grain yields.

The objectives of this study were;

(i) to characterize a tropical lowland maize population for genotypic variation in response to applied N fertilizer, and

(ii) to estimate the effectiveness of recurrent selection for improving grain yield and other important agronomic traits in the population under low levels of N fertilization.

Materials and methods

The maize population studied was Ejura 7843 C0, a population well adapted to growing conditions in Ghana. Ejura 7843 was derived from the second cycle of CIMMYT population 43 (commonly called La Posta) by intermating ten superior full-sib families selected from a replicated progeny trial at Ejura, Ghana in 1978. CIMMYT population 43 is a tropical lowland, white dent, late maturing Tuxpeno-related population that produces large vigorous-growing plants (CIMMYT, 1987).

In 1984, approximately 150 full-sib families were extracted from the cycle 0 of Ejura 784 at Kwadaso during the second growing season (August-December). No intentional selection was practiced during progeny formation. One hundred of these full-sibs were chosen for evaluation at 40 (low N) and 160 (high N) kg N ha-^{1}. Each N level was considered a separate field experiment. The two experiments were established adjacent to each other at Fumesua and Damongo in 1985 and at Nyankpala and Kwadaso in 1986. Nitrogen was applied at 40 and 160 kg N ha-^{1} as ammonium sulphate in equally split applications during the second and fourth weeks following emergence. All plots received 60 kg P2O5 ha^{-1} as triple superphosphate prior to planting. The trials were rainfed at all locations but supplemental irrigation was applied at Kwadaso because facilities were available.

The experimental design was a randomised complete block with a blocks-in-replications restriction on randomization for each N level. The 100 full-sibs wererandomly grouped into

10 sets of 10 families, which were randomly assigned to the 10 blocks in a complete replication, and the 10 families of each set were randomly assigned to 10 plots in each block. There were two replications in each environment. Plots consisted of a single row of each family, 5 m long at Fumesua and Damongo, but 3.5 m long at Nyankpala and Kwadaso. Row spacing was 0.8 m with 0.5 m between hills. Plots were over-planted and thinned to two plants per hill to give a uniform population density of 50,000 plants ha^{-1}.

Grain yield was reported in Mg ha^{-1} 150 g kg^{-1} moisture. Days to mid-silk was estimated as the number of days from planting to when 50% of the plants in a row had visible silks. Plant height was measured as the mean distance of five plants from the soil surface to the node of the lowest tassel branch. Lodging was visually scored on a 1 to 5 scale, with 1 = all plants erect and 5 = all plants broken below the ear or leaning at an angle greater than 45^{o}. Nitrogen stress was visually scored prior to flowering based on the number of chlorotic leaves and the extent of chlorosis per leaf with 1 = no stress and 5 = extreme stress. Ears were visually rated at harvest for acceptability based on uniformity of ear size, kernel rows, disease and insect damage, with 1 = good ear and 5 = poor ear.

Analyses of variance were computed for each environment (year-location) and combined over environments for each trait and level of N assuming all effects were random (Steel and Torrie, 1980). The pooled genotypic variances (over sets) were computed as follows:

Mean square (families in sets)

$$= \hat{\sigma}^2_e + 2\hat{\sigma}^2_{EG(s)} + 8\hat{\sigma}^2_{G(s)}$$

Mean square (families in sets x environment)

$$= \hat{\sigma}^2_e + 2\hat{\sigma}^2_{EG(s)}$$

Pooled error mean square

$$= \hat{\sigma}^2_e$$

where $\hat{\sigma}^2_{G(s)}$ is the pooled (over sets) genotypic variance among full-sib families, $\hat{\sigma}^2_{EG(s)}$ is the pooled full-sib family x environmental interaction variance, and $\hat{\sigma}^2_e$ is the pooled error variance. Variances of the estimates of genotypic and genotype x environment interaction variance components were computed following the procedure suggested by Comstock and Moll (1963). Mean performance of the full-sib families under each level of N was estimated for each trait by averaging the performance of the families in each environment and combined over environments. Estimates of genotypic (among full-sibs), genotype x environment, and error variances, heritability, and expected genetic gain from one cycle of full-sib selection were computed under each N level.

Results and discussion

Mean square estimates from the combined analysis of variance over environments for each N level showed all traits were significantly ($p < 0.01$) affected by environment (data not presented). Effects due to genotype were highly significant ($p < 0.01$) for grain yield at high N; mid-silk, grain moisture, and plant height at low and high N; and significant ($p < 0.05$) for grain yield at low N. No significant genotype effect was detected for lodging, ears per plant, N stress, and ear acceptability rating at both N levels. Genotype x environment interaction effects also were highly significant for nearly all traits at both N levels.

The relative importance of genotype and genotype x environment interaction effects to variation in each trait was determined by comparing the corrected sums of squares of the two sources. Genotype x environment interaction was more important than genotype, as a source of variation in grain yield and grain moisture, but was as important as genotype in mid-silk and plant height at either low or high N.

Mean performance of the full-sibs in all traits at each N level in each environment and averaged over environments is presented in Table 1. Growing conditions differed among the four environments which resulted in a wide variation in grain yield and plant height. Severe drought occurred at some stage of plant development in all test environments. Potential grain yield and plant height were substantially reduced at Nyankpala in 1986 because of heavy infestation of grasshoppers in addition to moisture stress. Irrigation was applied only at Kwadaso in 1986, when necessary, which resulted in Kwadaso being the highest yielding environment.

The mean grain yield at low N was approximately 9% lower than the yield at high N. The yield difference seemed small compared to the amount of fertilizer N applied at the low versus the high rate. Several reasons may be responsible for the small observed difference in yield. First, the environments probably masked yield response to applied N. Previous N fertilizer application, decomposition of organic matter, and atmospheric N fixation in thunderstoms may have produced these effects. Although grain yield was not estimated under unfertilized conditions in this study, estimates from a companion study (Sallah, 1989) were 3.0, 4.7, and 5.2 Mg ha^{-1} at 0, 80 and 160 kg N ha^{-1}, respectively. The relatively high yield observed under unfertilized conditions demonstrates the possible contribution of soil residual N to the N response observed in the present study. Third, the maize population studied may be unresponsive to high N fertilization, but this needs to be further investigated.

Mean days to mid-silk, grain moisture, plant height, ears per plant, and ear acceptability rating were similar

TABLE 1. MEAN PERFORMANCE OF 100 FULL-SIB FAMILIES FOR TRAITS MEASURED IN EACH ENVIRONMENT (ENV) AND COMBINED OVER ENVIRONMENTS.

Env+	N Level	Trait: Grain yield	Mid-silk	Grain moisture	Plant height	Lodging++	Ears per plant	Nitrogen* stress	Ear# acceptability
		Mg/ha	Days	g/kg	cm	score	no.	score	score
1	Low	4.72	61.5	232.6	213.9	2.0	0.89	2.0	2.8
2		5.09	62.6	233.6	200.2	3.1	0.97	-	2.6
3		3.91	58.8	299.1	163.8	2.6	1.02	3.1	3.5
4		7.07	57.3	239.5	208.3	1.1	0.97	2.3	2.4
	Mean	5.20	60.0	251.2	196.5	2.2	0.96	2.5	2.8
	SE	0.26	0.3	3.7	3.4	0.1	0.01	0.1	0.1
1	High	5.17	60.9	227.7	210.1	2.0	0.93	2.0	2.7
2		5.45	62.8	244.4	195.7	3.5	0.99	-	2.8
3		4.67	59.1	320.1	164.3	3.7	1.02	2.6	2.7
4		7.83	57.0	235.9	207.8	1.3	0.99	1.3	2.2
	Mean	5.78	59.9	257.1	194.5	2.6	0.98	1.9	2.6
	SE	0.26	0.3	4.2	5.9	0.1	0.01	0.1	0.1

\+ 1 = Fumesua 1985, 2 = Damongo 1985, 3 = Nyankpala 1986, and 4 = Kwadaso 1986.
++ 1 = all plants erect, 5 = extreme lodging.
* Data from 3 environments, 1 = no stress, 5 = extreme stress.
\# 1 = good ear, 5 = poor ear.

for both N regimes. Lodging was slightly more severe at high N and N stress was greater at low N. The N stress data at Nyankpala indicate the severity of N deficiency at low N. The high N environment at Nyankpala also showed a relatively high N stress score probably due to reduced N uptake and/or ineffective utilization of applied N in this environment.

Genotypic, genotype x environment, and residual variance estimates among the full-sibs, broad-sense heritability and expected gain from one cycle of recurrent selection for grain yield, mid-silk, grain moisture, and plant height are presented in Table 2. Genotypic, genotype x environment interaction, and error variance estimates for the four traits were greater than zero at either low or high N. Genotypic variance estimates for mid-silk, grain moisture, and plant height appeared to be greater at low N, but the genotypic variance for grain yield was greater at high N.

Genotype x environment interaction variance estimates were more important than genotypic variances for grain yield and grain moisture at both low and high N, and for plant height at high N, but were less important than genotypic variance estimates for mid-silk at both N levels and for plant height at low N. Error variance estimates were larger than either genotypic or genotype x environment interaction variances for all traits at each level of N. Larger plots and/or more than two replications per environment may be necessary to reduce the contribution of residual variance to phenotypic variation.

Heritability estimates calculated on family mean basis and expected gain from recurrent full-sib selection followed the same general pattern as genotypic variance estimates. Estimates of heritability for grain yield, days to mid-silk, grain moisture, and plant height in the population were in close agreement with those reported in the literature. The magnitude of heritability of a trait depends on whether its mode of inheritance is simple or complex and generally ranges below 0.3 for grain yield, and between 0.5 and 0.7 for days to flower, grain moisture, and plant height (Hallauer and Miranda, 1981). Selection for increased grain yield, reduced days to mid-silk, grain moisture, and plant height in the population would be effective under low or high N.

Maize breeding programmes traditionally develop improved cultivars for response to high N environments by applying high rates of N fertilizers to nursery and experimental plots. In the U.S. Corn Belt, the high grain productivity of maize is partly attributed to the ability of modern hybrids to respond to high plant populations, increased fertilizer application, and improved weed control (Russel, 1974; Duvick, 1977). Selection for response to high N environment may not be an appropriate breeding objective for areas practising low input agriculture or where the risk of groundwater contamination by residual nitrates through leaching is high. Under these circumstances, selection for response to relatively lowrates of fertilizer N

TABLE 2. ESTIMATES OF GENOTYPIC ($\hat{\sigma}^2_G$), GENOTYPE X ENVIRONMENT ($\hat{\sigma}^2_{GE}$), AND ERROR ($\hat{\sigma}^2_e$) VARIANCES, BROAD-SENSE HERITABILITY ($\hat{h}^2$), EXPECTED GENETIC GAIN (G_{FS}) FROM ONE CYCLE OF FULL-SIB FAMILY SELECTION FOR EACH N LEVEL.

Trait	N level	$\hat{\sigma}^2_G$	$\hat{\sigma}^2_{GE}$	$\hat{\sigma}^2_e$	$\hat{h}^2$	GFS^+
Grain yield (Mg ha^{-1})	low	0.058±0.030	0.080±0.055	0.885±0.066	0.309±0.159	0.24
	High	0.074±0.030	0.105±0.055	0.843±0.063	0.360±0.146	0.29
Mid-silk (Days)	Low	0.913±0.181	0.260±0.120	1.800±0.134	0.759±0.150	1.46
	High	0.598±0.136	0.115±0.131	2.160±0.161	0.667±0.152	1.11
Grain moisture (g kg^{-1})	Low	26.350±8.901	47.700±11.933	150.000±11.180	0.463±0.156	7.07
	High	13.150±6.270	43.000±10.089	122.900± 9.160	0.334±0.161	3.67
Plant height (cm)	Low	62.400±13.458	48.435±10.110	115.650±8.620	0.701±0.151	16.60
	High	55.625±13.253	72.105±11.526	107.060±7.980	0.639±0.152	10.46

Standardized selection intensity, K = 1.755.

may be more desirable. However, selection under extremely low levels of soil N should be avoided because such conditions would probably increase experimental errors, reduce seed yields, or result in poor pollination and low seed set (Balko and Russel, 1980; Muruli and Paulsen, 1981).

In conclusion, the study showed selection from the population for increased grain yield and selection for reduced days to mid-silk, grain moisture, and plant height would be effective at low or high N. However, selection for improved agronomic performance at high N rates may not be appropriate for areas practising low input agriculture and where contamination of groundwater by residual nitrates is probable.

References

Balko, L.G. and W.A. Russel (1980). Effects of rates of nitrogen fertilizer on maize inbred lines and hybrid progeny. I. Prediction of yield responses. Maydica 25:65-79.

Beauchamp, E.G., L.W. Kannenberg, and R.B. Hunter (1976). Nitrogen accumulation and translocation in corn genotypes following silking. Agron. J. 68:418-422.

Chevalier, P. and L.E. Schrader (1977). Genotypic differences in nitrate absorption and partitioning of N among plant parts in maize. Crop Sci. 17: 897-901.

CIMMYT (1987). CIMMYT Report on Maize Improvement. Mexico, D.F.

Comstock, R.E. and R.H. Moll (1963). Genotype x environment interactions. In W.D. Hanson and H.F. Robinson (Ed.). Statistical Genetics and Plant Breeding. NAR-NRC Publication 982. Washington.

Duvick, D.N. (1977). Genetic rates of gain in hybrid maize yields during the past 40 years. Maydica 22:187-196.

Hallauer, A.R. and J.B. Miranda (1981). Quantitative genetics in maize breeding. Iowa State Univ. Press, Ames, Iowa.

Krantz, B.A. and W.V. Chandler (1954). Fertilizer corn for higher yields. North Carolina Agric. Exp. Stn. Bull. 366.

Moll, R.H., E.J. Kamprath, and w.A. Jackson (1987). Development of nitrogen-efficient prolific hybrids of maize. Crop sci. 27:181-186.

Muruli, B.I. and G.M. Paulsen (1981). Improvement of nitrogen use efficiency and its relationship to other traits in maize. Maydica 26:63-73.

Pollmer, W.G., D. Eberhard, D. Klein, and B.S.Dhillon(1979). Genetic control of nitrogen uptake and translocation in maize. Crop Sci. 19:82-86.

Russel, W.A. (1974). Comparative performance for maize hybrids representing different eras of maize breeding. Proc. 29th Annu. Corn and Sorghum Res. Conf. 29:81-101.

Sallah, P.Y.K. (1989). Effects of six cycles of recurrent selection on the nitrogen response of a lowland tropical maize population in Ghana. Ph.d. Thesis, University of Minnesota, St. Paul, Minnesota.

Steel, R.G.D. and J.H. Torrie (1980). Principles and procedures of statistics. McGraw-Hill Book Company Inc., New York, NY.

Viets, F.G. (1965). The plant's need for and use of nitrogen. In W.V. Bartholomew and F.E. Clark (ed.). Agronomy 10:503-549.

Discussion

H. MERCER-QUARSHIE

In the past plant breeders were of the view that advances in selection would be retarded if high rates of fertilizers were not applied to selection plots. I am therefore happy to note from the work presented that indeed lower rates do not stand in the way of making good progress. Can the speaker explain how nitrogen stress scores are made?

P.Y.K. SALLAH

The system of scoring used for N stress was purely subjective. It was probably not a good way of estimating N stress, and may have accounted for the failure to obtain significant genotypic differences at both N levels for this trait. The problem arises because other superior methods could not be used in progeny trials as this involve large number of treatments. But I agree that other reliable means of estimating this trait should be sought.

D.K. ACQUAYE

Normally, a variety is high yielding either because it is efficient in the use of fertilizers and other inputs or because it has a more efficient mechanism for exploring the soil for nutrients. It is therefore necessary that in selection at low and high level of nutrients, the results should be put to economic analysis.

P.Y.K. SALLAH

Economic analysis will be necessary before a variety is released for production in low N environments, but we are not at that stage yet.

H.-K. HAUFFE

The increase in grain yield due to the high N application (160 kg/ha) was comparatively low. Are there observations, whether P, which was applied in 60kg P_2O_5 could have become significantly deficient?

P.Y.K. SALLAH

This is possible but I doubt if it is the case. Studies elsewhere have shown that tropical maize is relatively unresponsive to high levels of N fertilization. However, the effects of P will be explored in subsequent studies.

P.K. KWAKYE (UNIVERSITY OF CAPE COAST)

No soil analysis data were presented. It is important to properly characterise all experimental soils for easy interpretation of yield results.

(1) What are the reasons for the yield variability in the various environments?

(2) Why did you choose only two N rates and without a control?

P.Y.K. SALLAH

(1) Soil analysis was done but was not presented here because of time.

(2) Moisture stress occurred in all environments during some stage of plant development. However, irrigation was applied at Kwadaso in 1986 and this environment gave the highest grain yield.

(3) This study was not intended for estimating a N response curve and including a control was not necessary for achieving the stated objectives.

FOOD LEGUMES IMPROVEMENT AND THE IMPORTANCE OF LEGUMES IN THE CROPPING SYSTEMS OF NORTHERN GHANA.

K.O. Marfo

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Abstract

The major food legumes cultivated in the Guinea and Sudan Savanna Zones of Ghana include cowpea (Vigna unguiculata (L.) Walp.), groundnut (Arachis hypogaea (L.), bambarra groundnut (Vigna subterranea), and pigeon pea (Cajanus cajan(L.) Millsp.) These crops are important as sources of protein in local diets. Legumes are also important components of the farming systems in this region due to their ability to improve soil fertility through atmospheric nitrogen fixation. The major factors limiting production include biotic stresses such as diseases and insect pests, abiotic stresses such as drought, and, occasionally, excess moisture in years of high precipitation. In addition to these constraints, the local varieties grown by farmers have low yield potentials. The objective of the Food Legumes Improvement Programme of the Nyankpala Agricultural Experiment Station is to improve yield and yield stability of the important legumes for the savanna zone. This paper discusses some of the efforts being made to meet this objective through the development of improved varieties which have a range of growth cycle lengths and possess plant habits that suit the different cultural and environmental conditions prevailing in the zone.

Introduction

Groundnut, cowpea, bambarra groundnut and pigeon pea constitute the most important food legumes grown in Northern Ghana. Diseases, insect pests and unreliable rainfall distribution are the major yield reducing factors in this area. However, the total area under these crops, despite the low yields, has been increasing recently. This may be attributed partly, to the substantial quantities of atmospheric nitrogen these crops fix to help reduce the dependence of the average farmer on expensive inorganic fertilizers. Under a typical northern Guinea Savanna ecological zone as represented by Nyankpala, it was estimated that groundnut and soybean were able to fix 289 and 195 kg/ha of nitrogen, respectively. Corresponding figures for cowpea and bambarranut were 68 and 65 kg N/ha, respectively (Kaleem, 1990). As a result, groundnuts and cowpea witnessed about doublefold increase in cultivated area between 1986 and 1988 as compared with the period 1977 to 1984 (Table 1). The above reasons make it imperative for the Food Legumes Programme to concentrate on the following objectives;

(a) Developing stable and high yielding genotypes of the major food legumes

(b) Evolving varieties that are resistant to prevailing diseases and insect pests in these ecological zones

(c) Identifying varieties that are tolerant to abiotic stresses such as limited and erratic rainfall conditions with tolerance to high temperature conditions.

(d) Genotypes that are able to fix high amount of atmospheric nitrogen

(e) Developing crop varieties that combine acceptable seed qualities with production of substantial quantities of crop residues to be used as fodder in the dry season.

TABLE 1: ESTIMATES OF AREA CROPPED WITH GROUNDNUT AND COWPEA IN NORTHERN REGION BETWEEN 1977 AND 1988*

	Area ('000ha/annum)	
Crop	1977-1984	1986-1988
Groundnut	46.6	70.0
Cowpea	26.0	40.0

* **Source: Project Planning Monitoring and Evaluation Dept. (PPMED) of the Ministry of Agriculture**

Methodologies

The following strategies are employed to develop suitable varieties for widespread cultivation in the Guinea and Sudan Savanna Zones.

(a) Germplasm evaluation

Local materials as well as introductions from national, regional and international programmes are initially screened at Nyankpala. While the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is the major source of groundnut and pigeon pea germplasm, the International Institute of Tropical Agriculture (IITA) and the Semi-Arid Food Grains Research and Development (SAFGRAD) Project serve as sources of cowpea germplasm. The national programmes of Burkina Faso and Mali together with IITA provide our programme with bambarranut lines. After a year or two of the initial testing, desirable lines in terms of number of days to flowering, and maturity, grain or kernel yield, oil content (for groundnut), disease and insect pest reactions are pooled into multilocational tests at

Damongo, Manga, Nyankpala and Wa representing the major ecological zones of northern Ghana. These tests also last for two or three years, after which the high performing lines are further evaluated in on-farm tests for eventual recommendation for release.

The initial and multilocational tests are usually conducted in Randomized Complete Blocks with four replications. In cases where the number of entries exceed thirty, lattice designs are employed. Four row plots with each row measuring 4 m in length are utilized. The row to row and within row spacings adopted for cowpea are 60 and 20 cm, respectively. For groundnut and bambarranut, corresponding figures are 30, 45 or 60 cm x 10 cm for the erect, semi-spreading and spreading lines, respectively. Handweeding is performed when necessary to check weeds. Phosphorus is applied at the rate of 48 kg P_2O_5/ha as single superphosphate, broadcast before planting. While groundnut and bambarranut are never protected against insects, two or three sprays with insecticides comprising of Cymbush Super ED at 15 or 20 g.a.i./ha, Decis 2.5 E.C. at 12.5 g.a.i./ha or Roxion 40 EC at 400 g.a.i./ha are administered to cowpea and pigeonpea crops.

(b) Hybridization and selection

Concurrently, the Food Legumes Improvement Programme is introducing heat and Striga tolerant genes using pedigree-backcrossing into the genetic background of our cultivars. These lines are segregating for the above traits and seed coat color. Further advancement and selections will continue in future. A programme to improve on the field dormancy levels of some of our recommended groundnut lines are in progress.

Results and discussions

A major bottleneck to the development of broadly adapted food legume genotypes for Northern Ghana is the existence of genotype x environment interaction effects. This may be partly attributed to the erratic rainfall distributions in the zone. Genotypes evaluated multilocationally are subjected to yield stability analysis as a guide to the choice of the most stable genotypes for advancing to on-farm testing. The performance of some groundnut and cowpea lines tested at Damongo, Manga, Nyankpala and Wa in 1989 illustrate the variable responses of the genotypes under the different environments (Figs. 1

Fig. 1

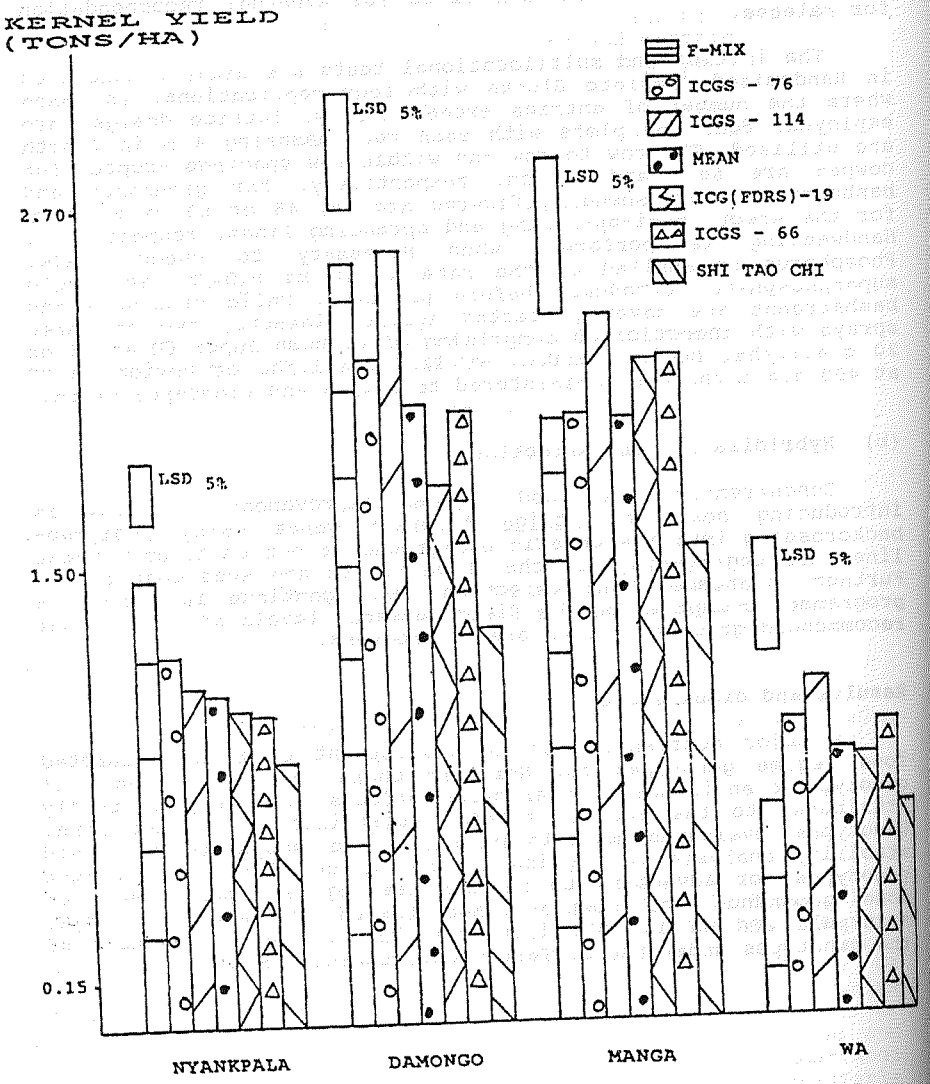

Fig. 1 : Performance of Six Groundnut Lines Evaluated at Four Locations in 1989.

Fig. 2

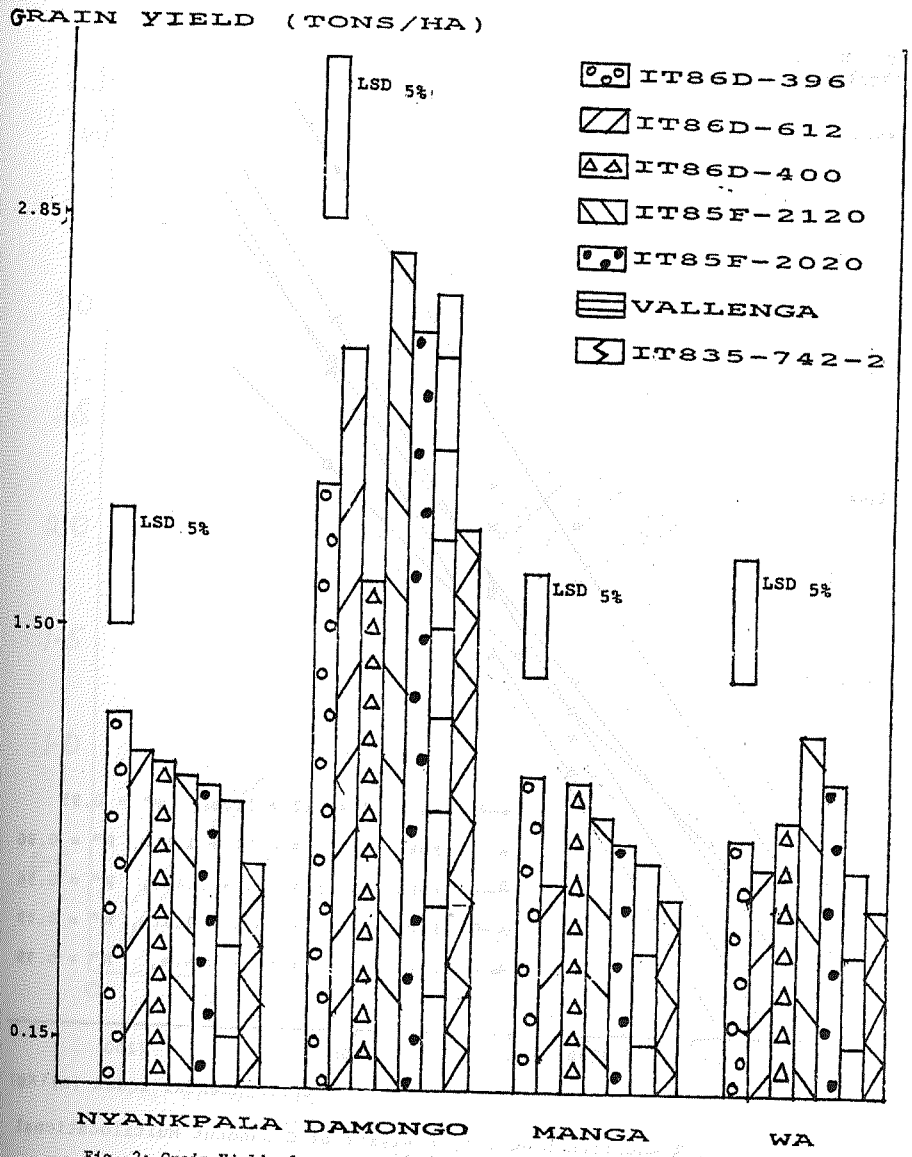

Fig. 2: Grain Yield of seven cowpea genotzpes tested multilocationally in 1989.

Fig. 3

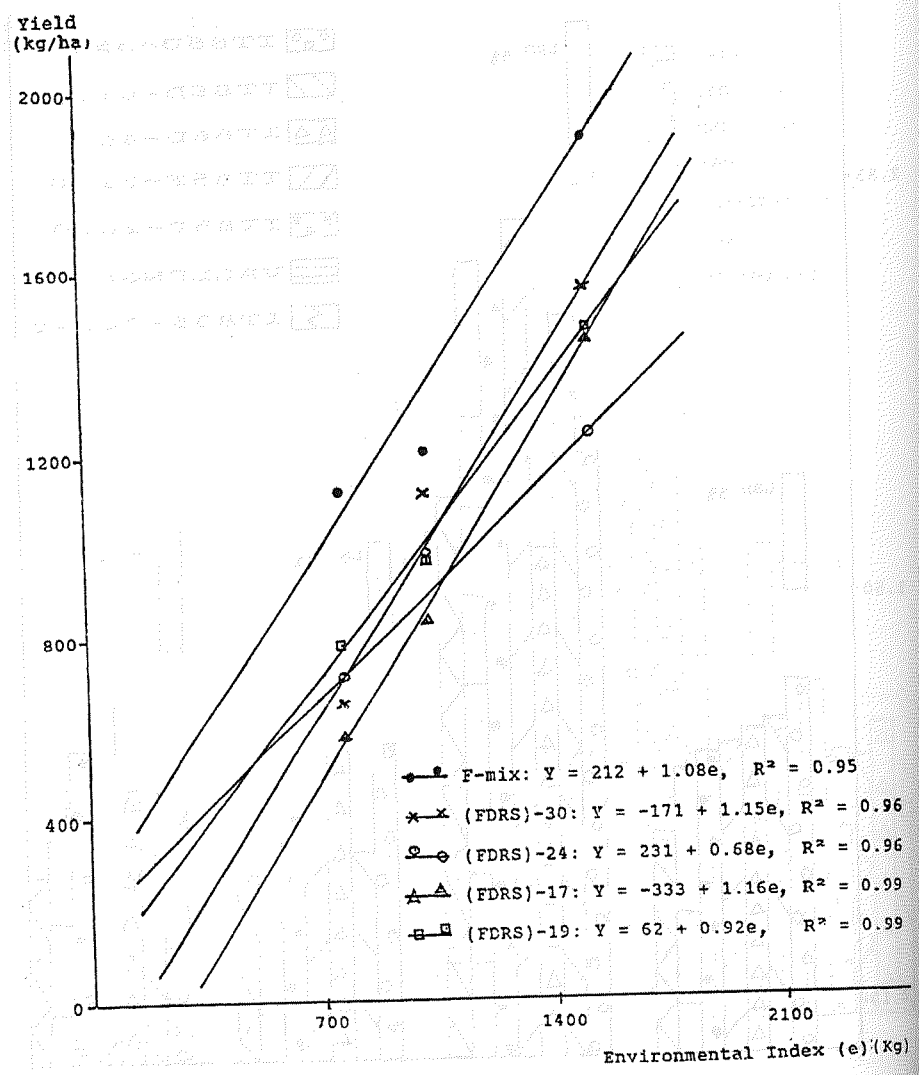

Fig. 3: Modified Stability Analysis of Groundnut Multilocational Yield Trials (1986-1989).

Fig. 4

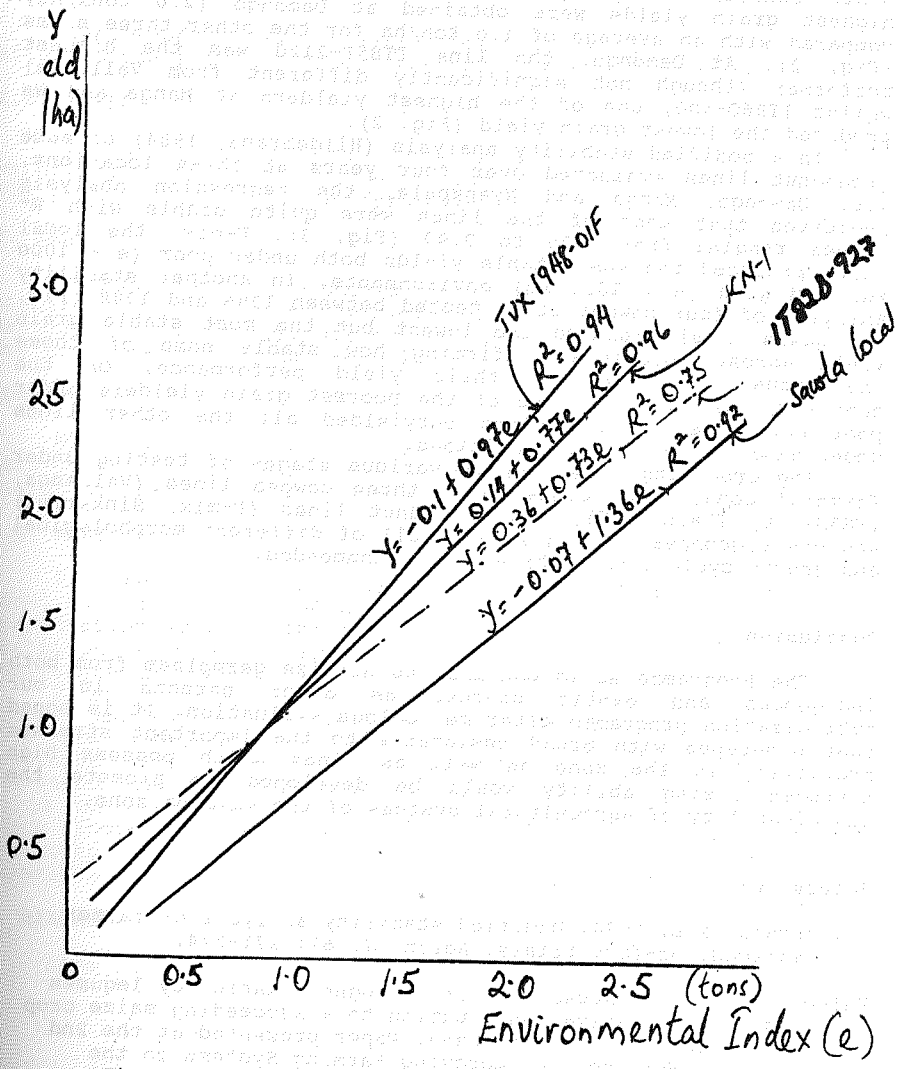

Fig. 4: Modified stability analysis of four cowpea lines evaluated at four locations. (1981)

and 2). Whilst the lines ICGS 114 and F-mix were the top performers at Damongo, Manga and Wa, F-mix outperformed all the other entries at Nyankpala (Fig. 1). Similarly for cowpea, highest grain yields were obtained at Damongo (2.0 tons/ha) compared with an average of 1.0 ton/ha for the other three sites (Fig. 2). At Damongo, the line IT85F-2120 was the highest performer (though not significantly different from Vallenga) whilst IT86D-400, one of the highest yielders at Manga and Wa produced the lowest grain yield (Fig. 2).

In a modified stability analysis (Hildebrand, 1984) of some groundnut lines evaluated over four years at three locations, i.e. Damongo, Manga and Nyankpala, the regression analysis indicates that most of the lines were quite stable with R^2 values ranging from 0.95 to 0.99 (Fig. 3). F-mix, the local check produced the most stable yields both under poor (e < 1000 kg) and good (e > 1000 kg) environments. In another stability analysis of four cowpea lines tested between 1986 and 1988 (Fig. 4), Sawla Local produced the lowest but the most stable grain yield across locations confirming how stable some of these indigenous lines are in their yield performance. On the contrary, TVX 1948-01F, one of the poorest grain yielders under poor environmental conditions outyielded all the other lines under good environmental conditions.

The promising lines are in various stages of testing under farmers' conditions. Since 1987, three cowpea lines (Vallenga, IT83S-818, IT81D-1137), two groundnut lines (F-mix, Sinkarzei) and one pigeonpea line (ICPL-270) all of different morphological and growth cycle lengths have been recommended.

Conclusion

The Programme would continue to utilize germplasm from both indigenous and exotic sources as donor parents in our hybridization programme after meticulous evaluation. It is hoped that genotypes with broad resistance to the important stresses prevailing in the zone as well as lines which possess high nitrogen fixing ability would be developed to promote the sustainability of agricultural systems of the savanna zone.

References

Hildebrand, P.E. 1984. Modified stability analysis of farmer managed, on-farm trials. Agron. J. 67: 271-274.

Kaleem, F.Z. 1990. Assessment of nitrogen fixation by legumes and their relative contribution to a succeeding maize crop in the savanna zone of Ghana. Paper presented at the 2nd National Workshop on Improving Farming Systems in the Savanna Zone of Ghana at Nyankpala, 24-26 April, 1990.

Discussion

J.A. ADOGOBA

The speaker has to make clear what conditions he meant affected the yields of his groundnut trials at Nyankpala?

K.O. MARFO

In 1989, I presume the excess moisture leading to waterlogged conditions on the fields might have resulted in the low yields of groundnut at Nyankpala.

P. SALLAH

COMMENT. Many procedures have been proposed to estimate stability of varieties across differing environments. These methods are fairly adequate but not the best. Dr. Marfo has used one of these recommended methods.

QUESTIONER

What programmes are available for the inclusion of local varieties in trials since most of these local types have certain qualities that could be better than introduced ones.

K.O. MARFO

I agree with you that we have to seriously start using our local materials as basis of improvement. I mentioned this in my presentation where I indicated there was going to be more co-operation with our entomologists in identifying sources of resistance in the local materials for insect pest resistance.

I have the belief some of the exotic materials "already cooked" do not perform well here just because the conditions here are different from the original place where they were developed. For example, aphid resistant cowpea materials evaluated here from IITA are invariably not resistant. I suspect it is the fact that the biotypes here may be different ones. Hence there is the need in doing our own development of varieties here or where this is not possible, segregating materials should be screened under our conditions.

A. MISSAH

Does the station do adequate conservation of germplasm?

K.O. MARFO

Not exactly. This is because our cold facilities are not operative. Thus the only conservation manner is through regeneration on the field. Where we are not able to do that, it results in the erosion of our germplasm, thus forcing us to fall back on our Plant Introductory and Conservation Station at Bunso or the original place where we had it from.

D.K. ACQUAYE

How did you derive your environmental index used in the figure relating yields to environmental index in your regression analysis?

K.O. MARFO

The environmental index is derived by estimating the mean yields of all the varieties tested in a particular location. Thus for example, each station will have a different environmental index leading to 4 points on the environmental index axis.

A.B. SALIFU

Can you comment on the tolerance mechanism in your striga tolerant line?

K.O. MARFO

I am not very sure of the mechanism but I suspect antibiosis may be involved. However, there are some fields where one observes the presence of the striga but still yields are not appreciably affected. Perhaps the striga effect did set in a little bit late when reproductive development (major part) had already taken place.

STRATEGIES FOR SOYA BEAN IMPROVEMENT IN NORTHERN GHANA

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The soya bean which is said to have originated from north China and which was thought to be primarily a temperate crop has in recent years began to assume importance even in the tropical regions of the world as varieties adapted to these regions are developed. The crop is best known for its high protein content. The incorporation of soya bean in the Ghanaian diet can help alleviate protein malnutrition in the country. The soya bean can be incorporated into nearly every food normally eaten by Ghanaians. It has in addition an oil content of 20 percent.

The soya bean is relatively free from diseases and pests and therefore does not require the application of excessive pesticides. Its cultivation does not require any major changes in the cropping system currently practiced in the interior savanna zone.

Products of the crop are already imported into the country. It has been reported that about US $5 million worth of soya bean meal for livestock feed manufacture and soya oil for home consumption is imported annually.

While the cultivation of soya bean is expanding, the acreage under soya beans remains small primarily because most farmers do not know about the crop and those who know about it do not have adequate marketing opportunities for their production. Added to this are some technical constraints. The Nyankpala programme seeks to find solutions to the technical constraints with the hope that Government policy will also be focussed on mitigating the other constraints.

Programme assumptions, objectives and priorities

The programme assumes that the crop would be grown by small scale farmers. It also assumes that for a long time to come the crop will not be given the same priority attention as given the cereals, and that it will be grown as an intercrop or in relay or in rotation with other cereals and legumes, and that a substantial portion of the production will be for home consumption.

Objectives of the improvement programme are;

1. High and stable yield

Varieties that perform well relative to others under northern Ghana conditions are desired. Rainfall in the region is unpredictable and can range from 600-1200 mm annually. Soils also vary from highly fertile ones as found in Damongo to partly eroded ones in Bolgatanga on which only millets do well. Varieties that give good yields under these conditions even when they are intercropped with other crops are sought.

2. Seed longevity

Loss of seed viability in storage soon after harvest and consequently poor stands in the field is a major constraint to soya bean cultivation in Ghana. Although the rapid loss of seed viability is not fully understood the wide range of temperatures of 15° to 46°C and humidity from 15 - 85% during the period of storage must contribute to the problem. Varieties which maintain high germination even under such varying conditions are looked for in the breeding programme.

3. Promiscuous nodulation

Until a few years ago none of the varieties introduced from the USA formed nodules with native rhizobia. Even though such varieties now form nodules probably because compatible rhizobia have been selected as a result of repeated soya bean cultivation, there is still the need to identify varieties which will form very effective nodules as to make the application of inoculants superfluous.

4. Resistance to shattering

There has been some improvement in developing shatter resistant varieties. However, because of rapid dessication of the savanna at the end of the rains shattering of the crop is still a problem. The breeding programme will look for even more resistance to this constraint.

5. Maturity period

It is expected that soya beans will be grown in intercropping, strip cropping, relay cropping and rotational systems in areas with varying growing periods. The programme aims at developing early (90 - 95 days) medium (100 - 110 days) and late (120 - 135 days) maturity types to suit the different growing conditions.

6. Pests and disease resistance

Apart from bacterial pustule and occasional mosaic virus no serious diseases have been encountered so far. Among pests, the only major ones are nematodes Melodogynae incognita which occur in irrigated plots on which tomatoes have been grown repeatedly. The situation is likely to change as more soya beans are grown. Pest monitoring will therefore be undertaken regularly.

Numerous other traits are also of some interest even though they are of less priority now. Included in this group of characters are plant height, height of first pod, resistance to lodging, seed size, colour of seed, photo-period insensitivity, oil content, protein content and resistance to rodents.

Breeding procedure

Introduction of germplasm

Soya bean is not an indigenous crop and has only recently been introduced. There are therefore no local collections to be made. There are, however, international institutes with strong breeding programmes. The Nyankpala programme therefore depends a great deal on these institutes for germplasm. Experience in the last seven years shows that the most dependable institutes from which genotypes adapted to our conditions can be introduced are IITA in Nigeria and AVRDC in Taiwan. Materials have also been introduced from INTSOY in Illinois and the Mississippi Agricultural and Forestry Experiment Station, Stoneville, both in the USA and from other national programmes in Zimbabwe and Senegal. From 1983 until now over 1000 lines or varieties have been introduced.

Evaluation of introduced germplasm

The introduced germplasm go through the following steps in the process of evaluation.

(a) Initial screening nursery

The materials are planted at Nyankpala in single or duplicate rows and are replicated or not depending on the seed available. At this stage data recorded include days to flower, flower colour, height of first pod, number of pods/plant, plant height, maturity, grain yield, seed size and colour, pest and diseases, nodulation, resistance to lodging and shattering, seed quality and seed longevity.

Preliminary yield evaluation

The genotypes that show promise in the first step are advanced to the preliminary yield evaluation nursery where the entries are planted only at Nyankpala in a 4-replicated trial. Notes taken are similar to those recorded in the initial screening nursery.

Advanced station trials

The best lines from the preliminary yield evaluation which may not be more than 20 enter the advanced station variety trials which usually are sited at three locations.

Two more years of station trials may be conducted with the expansion of the experiment onto two additional locations.

On-farm trials

The best 1 - 3 lines from the station trials are advanced to on-farm trials for a year or two.

Recommendation

Seed of the best line from the on-farm trials is then increased for the seed producers and the variety named and recommended.

Hybridization programme

In the last four years the programme has initiated crosses with the view to enhance the achievement of the objectives already discussed. With the emphasis now on yield and seed longevity, only few crosses, 2 - 4 are made every year among adapted parental lines. Some attention is also being given to the development of adapted varieties with the hard seed trait by transferring that character to otherwise desirable lines.

The procedure of the hybridization programme is as follows;

(a) Two to four crosses are made in the rainy season in the field.

(b) The F_1 is grown in the mesh-house in early November and harvested in February.

(c) The F_2 is space planted also in the mesh-house and harvested at the end of June with no selection.

(d) The F_3 is grown head to row in the rainy season. There may be for each cross about 800 rows. At intervals of 20 rows parental lines are grown to serve as checks. Based on maturity, profuseness of podding, disease resistance and shattering resistance plants from the best 25% rows are selected.

(e) F_4 plants from the selected rows are evaluated in an early generation performance test, (Voigt & Weber, 1960) generally in a simple lattice design with 2 replications at an irrigated site. Based on yield, shattering resistance, promiscuous nodulation, disease resistance and maturity, plants from 50% of lines are selected for further testing.

(f) In the F_5 an initial performance evaluation is conducted at two locations generally with about 100 lines also in a simple lattice design with 2 replications. The best 20% of the lines are retained for the next stage in the testing programme.

(g) In the F_6 generation the lines enter the advanced station variety trials. The trial is usually replicated four times and is conducted in 3 locations with 20 entries.

(h) The advanced station variety trial is repeated for 2 years in the F_7 and F_8 generations with an increase in number of sites to 5 and a reduction in number of entries to under 20.

(i) At the F_9 on-farm trials are initiated with the best 2 - 5 lines.

(j) Seed increase of the best line is undertaken and the variety named and recommended to seed producers.

Results of hybridization programme

Table 1 shows some results of the hybridization programme.

In 1988 the performance of thirty four F_5 lines from 3 crosses were compared with 15 current varieties.

The mean yield of lines derived from Nakpanduri x Improved Pelican, Otootan x TGM 1171 and Bossier x Otootan crosses and 15 varieties was 953 kg/ha. The mean yields of the lines derived from Nakpanduri x Improved Pelican and Otootan x TGM 1171 and the current varieties were 1008, 1021 and 887 kg/ha, respectively (Table 1) which showed that the crosses outyielded the existing varieties. However, the mean yield of Bossier x Otootan derived lines was only 824 kg/ha and did not exceed that of the 15 current varieties. The overall trial mean yield was exceeded 75, 60 and 16% by the lines derived from Nakpanduri x Improved, Pelican, Otootan x TGM1171, and Otootan x Bossier crosses, respectively. Of the current varieties tested only 3 of them exceeded the overall trial mean yield. The Nakpanduri x Improved Pelican and Otootan x TGM 1171 crosses were clearly superior in yield to the Otootan x Bossier and the current varieties. Of the five best lines in the trial, 4 were derived

TABLE 1: MEAN YIELD OF F_5 LINES FROM CROSSES AND 15 VARIETIES AT NYANKPALA, 1988

Cross/Entries	Mean yield (kg/ha)	Range (kg/ha)	% entries exceeding trial mean yield
Nakpanduri x Improved Pelican (8 lines)	1008	641-1417	75
Otootan x TGM 1171 (20 lines)	1021	623-1619	60
Otootan x Bossier (6 lines)	823	674-1004	16
15 Varieties	887	506-1262	20

from Otootan x TGM 1171 and one from Nakpanduri x Improved Pelican cross.

Evaluation of introduced varieties

From 1983 up to now the station has evaluated a large number of both medium and late maturity varieties introduced from other breeding programmes.

Medium maturity varieties

Mean yields of 20 medium maturity varieties compared at four locations from 1986 to 1988 are shown in Table 2. Mean yields at Nyankpala in 1986, 1987 and 1988 were 742, 752 and 1560 kg/ha, respectively. Yields in the first two years were about half the normal while the 1988 yields were as expected. The yields in the different years were a good reflection of the rainfall in those years. In 1986, TGX 536 - 02D gave the highest yield but it was not significantly different from Salintuya-1. In 1988 Salintuya-1 gave the highest yield at Nyankpala. When the entries are ranked based on yield performance the best varieties are TGX 536-02D, Salintuya-1, TGX 297-35C and TGX 536-100C.

At Damongo the mean yields were 1757, 1469 and 1652 in 1986, 1987 and 1988, respectively. Whereas the mean yields of 1986 and 1988 were close to the average expected of 2000 kg/ha at that location, that of 1987 was rather low. In 1986 and 1988 none of the varieties significantly outyielded Salintuya-1 even though TGX 297 - 35C gave a higher yield. In 1987 Salintuya-1 was significantly outyielded by a number of varieties including TGX 536-100C, and ISRA/IRAT 126/72. When the varieties are

TABLE 2: YIELD (KG/HA) OF MEDIUM MATURITY VARIETIES OF SOYA BEANS AT 4 LOCATIONS 1986 - 1988

Entries	Nyankpala			Damongo		Manga		Yendi		Mean
	1986	1987	1988	1986	1987	1988	1986	1988	1988	
TGX 297-35C	830	766	2240	2270	2292	2077	1348	258	1641	1525
TGX 299-6F	-	-	1854	-	-	1883	-	499	2961	1799
TGX 536-02D	964	967	2288	1550	1614	1929	1262	363	1483	1380
TGX 536-100C	720	1054	1728	1579	2718	1041	1644	319	1212	1335
M 79	890	996	1488	2106	1814	1438	1285	234	1637	1321
ISRA/IRAT 126/72	645	1962	1415	645	2067	1297	1600	388	1521	1282
TGX 744-01E	712	838	1611	2520	1518	1929	1170	267	638	1245
TGX 539-5E	-	-	1369	-	-	1887	-	314	1271	1208
TGX 849-294D	-	-	1541	-	-	1707	-	694	833	1194
TGX 573-6C	754	975	1213	1197	1868	1817	1362	459	1065	1190
Salintuya - 1	741	1017	2290	1775	998	1799	802	424	436	1142
TGX 382-375D	798	537	2077	1993	1309	1748	972	263	566	1140
Nakoanduri	565	347	1722	1901	1706	1778	817	384	1029	1139
TGX 536-100C-Y	710	1042	1959	1355	1330	1581	1115	251	754	1122
PR 13 (114)	766	676	1458	1665	1395	1634	733	434	831	1066
TGX 724-01D	647	474	965	1579	1056	1499	1869	434	664	1021
M 90	725	359	1289	1100	1257	1960	1117	424	643	986
TGX 711-01D	609	608	850	1659	1061	1364	974	430	732	921
AC 2120	-	-	894	-	-	1328	-	313	532	767
Papillon	647	267	1027	1637	411	1344	771	269	484	762
Mean	742	752	1560	1757	1469	1652	1134	371	1047	1177
L.S.D. (05)	399	549	890	786	726	803	634	233	771	
S.E.	141	210	314	278	328	284	224	82	272	
C.V.	38	40	40	31	34	34	39	44	42	

Table 2 Yield (kg/ha) of medium maturity varieties of soya beans at 4 locations 1986 - 1988.

ranked based on yield, the best varieties are TGX 297-35C, TGX 744-01E, TGX 536-02D and Nakpanduri.

At Manga the crop failed in 1987 as a result of very poor stands. The yield results obtained in 1986 were normal but those obtained in 1988 were only about a third of the expected. In 1986 Salintuya-1 was outyielded by TGX 536-100C, ISRA/IRAT/126/72 and TGX 724-01D. In 1988 Salintuya-1 was outyielded by only TGX 849-294D a variety which was included only in 1988. When the varieties are ranked based on yield, the best varieties are TGX 724-01D, TGX 573-6C, TGX 536-100C and M 90.

The trial was carried out at Yendi only in 1988. The highest yield in all the three years of trial of 2961 kg/ha was obtained from TGX 299-6F at Yendi. The mean yield of 1047 kg/ha was only about 60% of the expected. Six varieties including TGX 297-35C, TGX 536-02D, ISRA/IRAT 126/72 and M 79 significantly outyielded Salintuya-1.

Late maturity varieties

Mean yields of 20 late maturity varieties compared at four locations from 1986 to 1988 are shown in Table 3. In general the mean yields obtained in the different environments corresponded to what was observed with the medium maturity varieties. Yields obtained in 1988 were higher than in the other two years.

At Nyankpala mean yields in 1986, 1987 and 1988 were 794, 936 and 1206 kg/ha, respectively. Only the 1988 yields approached the normal. In the poor years of 1986 and 1987 Salintuya-2, the recommended variety, was not exceeded significantly in yield by any other variety. In 1988 Salintuya-2 was significantly outyielded by TGX 297-10F and TGX725-011D, two new introductions. When the varieties are ranked based on yield the best varieties are PR 21(309), F75-9207, Salintuya-2 and TGX 307-047D.

At Damongo mean yields in 1986 approached the 2000 kg/ha expected. The mean yields of 852 and 1323 kg/ha in 1987 and 1988 respectively, were about 50% of the expected. In 1986 only one variety PR 21(309) significantly outyielded Salintuya-2 but in 1987 five varieties did so including PR 21(309). However, in 1988 Salintuya-2 was the highest yielding variety even though its yield was not significantly different from six other varieties. When the varieties are ranked based on yield the best varieties are TGX 307-048D, PR 21(309), TGX 307-047D and Salintuya-2.

At Manga again owing to poor germination no data could be obtained in 1987. Yields in both 1986 and 1988 were very low for reasons that are not apparent at this time. In 1986 Salintuya-2 was the second highest yielding variety after Baru, and was significantly outyielded by only one variety TGX 297-10F in 1988. At this location yield ranks show that the best varieties are PR 21(309), Baru, TGX 742-02D and Salintuya-2.

At Yendi where the trial has been conducted for only one year the highest yielding varieties are TGX 297-10F and TGX 725-

TABLE 3: MEAN YIELD (KG/HA) OF LATE MATURITY VARIETIES OF SOYA BEANS AT 4 LOCATIONS, 1986 - 1988

Entries	Nyankpala 1986	Nyankpala 1987	Nyankpala 1988	Damongo 1986	Damongo 1987	Damongo 1988	Manga 1986	Yendi 1988	Yendi 1988	Mean
TGX 297-10F	-	-	2267	-	-	2080	-	541	2457	1836
TGX 725-011D	-	-	1765	-	-	1088	-	367	2542	1441
TGX 293-63F	-	-	1134	-	-	1902	-	407	1850	1322
TGX 814-27D	935	-	1541	-	-	1681	-	443	1507	1293
PR 21 (309)	790	1152	1413	2730	1388	764	634	405	1044	1163
TGX 307-048D	943	899	873	2140	1351	2056	523	279	834	1083
Salintuya-2	863	1027	1025	1529	470	2163	661	292	1052	1018
TGX 307-047D	983	1253	993	1932	1040	1195	525	165	1136	1011
Baru	773	1148	952	1678	885	1024	836	365	1073	994
F 75-9207	632	1328	1230	2237	591	1016	409	220	1038	982
TGX 330-03E	676	1079	1045	1915	1261	1185	424	238	948	970
TGX 742-02D	632	1008	1263	746	885	1499	710	398	998	909
TGX 356-055D	-	985	1407	1376	557	1349	603	224	772	878
TGX 342-356	1075	-	1090	-	-	1493	-	288	591	866
IAC-6	821	549	994	2073	812	693	409	322	861	865
TGX 307-043D	569	806	928	1105	1305	1136	489	226	731	839
TGX 573-104C	1090	616	568	1583	921	1437	775	380	649	833
TGX 709-06D	838	610	912	1817	562	1071	378	205	659	812
Jupiter	384	848	1120	1439	349	1162	475	315	484	781
Egsy-91-7		860	1606	1640	637	474	529	230	543	767
Mean	794	936	1206	1730	852	1323	605	315	1088	1033
L.S.D. (05)	472	466	558	675	466	247	212	76	334	
S.E.	166	199	197	237	189	247	212	76	334	
C.V.	41	37	32	27	37	37	40	48	42	

Table 3 Mean yield (kg/ha) of late maturity varieties of soya beans at 4 locations, 1986 - 1988

011D. Both of them significantly outyielded Salintuya-2. A few more years of trials are required for a more definite information on performance of varieties at this location.

Recommendation of varieties

When the medium maturity varieties that have been tried in at least nine environments and on whose data greater reliance can be placed are considered, the highest yielding six varieties in a descending order are listed in Table 4 together with the mean of their agronomic characters. The variety TGX 297-35C which was the best (lowest ranking value) gave a mean yield of 1525 kg/ha and a yield range of 258 - 2270 kg/ha but produced the lowest number of nodules per plant, and a higher number of stands than most of the varieties. The mean yields of the six varieties were, however, not significantly different. Salintuya-1 with a mean yield of 1142 kg/ha ranked lowest (highest ranking value) but produced the highest number of nodules per plant. The higher mean yield of TGX 297-35C in addition to its higher number of stands make it worth considering for recommendation.

TABLE 4: MEAN PERFORMANCE OF THE BEST SIX MEDIUM MATURITY VARIETIES OF SOYA BEANS OUT OF TWENTY AT FOUR LOCATIONS, 1986 - 1988.

Entries	Yield kg-ha^{-1} Mean	Range	Mean^{+} yield rank	% Stands per plot	No. of nodules per plant
TGX 297-35C	1525	258-2270	5.3	66	0.9
TGX 536-02D	1380	363-2288	6.7	81	3.8
TGX 536-100C	1335	388-2718	7.4	53	1.3
ISRA/IRAT 126/72	1282	338-2067	7.8	49	3.6
M 79	1321	234-2106	8.2	52	5.9
Salintuya-1	1142	434-2290	10.3	50	12.1
Mean	1331		7.6	56	4.6
LSD P = 0.05	402			38	3.9

$^{+}$The average of all trials with the best entry in each trial ranked 1 and the worst 20.

TABLE 5: MEAN PERFORMANCE OF THE BEST SIX LATE MATURITY VARIETIES OF SOYA BEANS OUT OF TWENTY AT FOUR LOCATIONS 1986 - 1988

Entries	kg-ha^{-1} Yield					
	Mean	Range	Mean^{+} yield rank	% Stands per plot	No. of nodules per plant	shattering* score
PR 21(309)	1163	405-2780	5.4	50	7.1	1.9
Baru	994	365-1678	8.0	82	11.1	1.0
Salintuya-2	1018	292-2163	8.3	70	7.7	2.1
TGX 307-047	1011	165-1932	8.7	65	2.9	1.3
TGX 307-048	1083	279-2140	9.0	59	8.6	2.0
F75-9207	982	220-2237	11.2	65	7.6	2.0
Mean	1042		8.4	65	7.5	1.7
LSD.P. = 0.05	366			36	6.0	0.7

* Shattering score, 1 = no shattering, 5 = all pods shattered
\+ The average of all trials with the best entry in each trial ranked 1 and the worst 20.

When late maturity varieties that have been tested in at least nine environments are considered, the highest yielding varieties in a descending order are PR 21(309), Baru, Salintuya-2, TGX 307-047D, TGX 307-048D and F75-9207.
Table 5 shows some agronomic characters of these varieties. The variety PR 21(309) which ranked highest (lowest rank value) gave the highest mean yield of 1163 kg/ha but the lowest % stands per plot. The mean yields of the six varieties were not significantly different. The recommended variety, Salintuya-2, ranked third with a mean yield of 1011 kg/ha, had a higher % stands per plot and a higher number of nodules than PR 21(309). It was also resistant to shattering. This variety must therefore stand as the recommended variety amongst the late maturity group.

Comparison of medium and late maturity varieties

Late maturity varieties adapted to lower latitudes are generally expected to give higher yields than medium maturity ones (Cianzio, 1985). Table 6 shows a comparison of the mean yields of the two maturity groups tested in nine environments. In six of the environments including all the trials at Damongo and Manga the medium maturity types outyielded the late maturity ones significantly in some cases. In three environments the late maturity means exceeded but not significantly the medium maturity means.

Table 7 also compares the yield ranges of the late and medium maturity varieties. In six of the environments the lowest yielding variety of the medium maturity group exceeded that of the late maturity group. In two cases the lowest yielding late variety exceeded that of the medium maturity variety. Again, in six environments the highest yield of a medium maturity variety exceeded that of the late maturity one. It may be added that a higher mean yield of a maturity group in an environment was not always reflected in a higher point in the yield range. From the foregoing, the yield superiority of the late maturity varieties was not apparent. In fact, the medium maturity varieties seemed to have a slight yield edge over the late

TABLE 6: COMPARISON OF MEAN YIELDS (KG/HA) OF MEDIUM AND LATE MATURITY VARIETIES IN NINE ENVIRONMENTS

Variety Type	Nyankpala			Damango			Manga		Yendi
	1986	1987	1988	1986	1987	1988	1986	1988	1988
Medium maturity	742	752	1560	1757	1469	1652	1134	371	1047
Late Maturity	749	936	1206	1730	852	1323	605	315	1088

TABLE 7: COMPARISON OF YIELD RANGES (KG/HA) OF MEDIUM AND LATE MATURITY VARIETIES IN NINE ENVIRONMENTS

Variety Type	Nyankpala			Damongo			Manga		Yendi
	1986	1987	1988	1986	1987	1988	1986	1988	1988
Medium Maturity	565-964	267-1962	850-2290	645-2520	998-2292	1328-2077	733-1869	234-694	484-2961
Late Maturity	384-1075	549-1328	568-2267	746-2730	349-1388	474-2080	378-836	165-541	484-2542

maturity ones. It is probable that the slightly poorer performance of the late maturity types results from the early cessation of rains which, on occurring during pod-filling stage, causes considerable yield reduction (2,3,4).

Conclusions

Results presented show that

i. Availability of an irrigation facility could shorten the process of developing improved varieties

ii. The chances of selecting superior lines through the use of early generation tests are good. In crosses made so far Otootan x TGM 1171 has proved to be a superior combination.

iii. The medium maturity variety TGX 297-35C was the only variety that came close to being significantly better than Salintuya-1 thus making it worth recommending.
However, among the late maturity varieties Salintuya-2 must still remain the recommended variety.

iv. Contrary to expectation the medium maturity varieties have a slight yield advantage over the late maturity ones in the interior savanna zone.

References

Cianzio S.R. de. 1985. Off-season nurseries enhance soybean breeding and genetics programmes. p. 329-336. In Richard Shibles (ed). Proceedings World Soybean Research Conference III. Westview Press Inc. Boulder, Colorado U.S.A.

Runge E.C.A., and R.T. Odell 1960. The relationship between precipitation, temperature and the yield of soybeans on the Agronomy South Farm, Urbana, Illinois, Agron. J. 52:245-2.

Shaw R.H., and D.R. Laing 1965. Moisture stress and plant response p.73-94. In Plant environment and efficient water use. Amer. Soc. of Agronomy. Madison Wisconsin.

Thompson L.F., and G.W. Hardy. 1970. Weather and technology in the production of soybeans in the Central United States. Agron J. 62:232-236.

Voigt, R.L., and C.R. Weber. 1960. Effectiveness of selection methods for yield in soybean crosses. Agron. J. 52:527-530.

Discussion

H. RUDAT

Are we able to reduce the breeding cycle of the crop?

S. FLEISCHER

We can do this if we have adequate irrigation facilities.

QUASHIE-SAM

How do you determine the best variety? Is it based on yield alone?

S. FLEISCHER

The best variety must have all the important traits set out in the objectives. They include seed longevity,shatter resistance, pest and disease resistance.

S.Z. ABDEL-RAZAQUE

Creamy colour is preferred by industrialist and food specialist and GFDC.

S. FLEISCHER

Thank you for the information.

S. TWUMASI-AFRIYIE

(1) The series of testing - namely, initial, prelimi- nary, on-station, on-farm trials appear too long and may be shorter if on-farm testing should be multilocation and overlap with station testing.

(2) Are there colour preferences in soybean and which colours are preferred?

S. FLEISCHER

On-farm trial results incorporate both biological and socio-economic outcomes. we generally go on-farm when there are only a few varieties 1-3 to be tested. We cannot therefore combine the advanced station trials with on-farm activities.

(2) In the Upper East the preference is for black seed varieties. In the Upper West and Northern Regions the preference seems to be cream coloured seed.

P. OSEI-BONSU

Which maturity group of soybean did you achieve in your breeding (hybridization) programme?

S. FLEISCHER

Three maturities are sought after in the breeding programme. They are early, 90-95 days, medium, 100-110 days, and late maturity, 120-135 days.

REVIEW OF LATEST RESULTS OF ICRISAT SORGHUM REGIONAL PROGRAMME BASED IN MALI

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Abstract

ICRISAT West African Sorghum Improvement Programme (WASIP) strengthened its research on sorghum by posting two complementary teams, one in Bamako, Mali and another in Kano, Nigeria. The programme identified improved sources of resistance to various biotic yield reducing factors. Sorghum varieties like 84 S 82, 84 S 103-2 and 84 W 838 exhibited resistance to leaf anthracnose, grey leaf spot and sooty stripe. Among the insects, we confirmed the resistance of CSM 388 and Mali Sor 84-7 to headbugs and transferred successfully the resistance to midge into locally adapted high yielding varieties. We started verifying the potential of integrated Striga control packages in heavily infested farmer's fields. We identified promising sorghum varieties (ICSVs 1063, 1079 and 111) and hybrids (ICSH 507) which are in various stages of testing in different countries. The food quality and industrial utilization of sorghum grain is receiving more attention. The major focus of WASIP is to develop sustainable sorghum based cropping systems for different ecological zones of West Africa. We started fine tuning intercropping systems like sorghum/cowpea and sorghum/groundnut. These technologies will be tested on farmers' field in collaboration with national programmes. The future prospects are outlined.

Introduction

During the last two decades (between 1965 and 1985), the area sown to sorghum in West Africa increased at an annual compound growth rate of 0.7%, but the production decreased at 0.4% (ICRISAT 1988a). This was reflected in a reduction of 3.4% per habitat during the same period (FAO 1988). These figures clearly demonstrate the need for more sustained production of sorghum, one of the staple cereals of West Africa.

The West African Sorghum improvement Programme (WASIP) of ICRISAT addresses the problem of sorghum production in the region through research and training.

WASIP is divided into two teams, one based in Kano, Nigeria (WASIP N), one in Bamako, Mali (WASIP M).

The WASIP (M) team consists of 5 sorghum scientists including 4 from IRAT; they are two sorghum breeders (one each from IRAT and ICRISAT), one pathologist (ICRISAT), one entomologist (IRAT) and one economist (ICRISAT).

This team closely works with the national programmes of 9 countries (Mali, Burkina faso, Côte-d'Ivoire, Senegal, Gambia, Mauritania, Sierra Leone, Guinea and Guinea Bissau.

In this paper, the latest results of WASIP (M) are reviewed.

Objectives

The objectives of WASIP (M) are to;

(i) Cooperate with the national agricultural research and extension systems in large scale evaluation of high yielding cultivars and technologies. In the cooperating countries; generate and evaluate breeding lines for higher yield and resistance to multiple stress factors in order to identify high yielding stable cultivars that are acceptable to the farmers;

(ii) develop sorghum based cropping systems that maintain soil fertility, minimise erosion and structural damage to soil and at the same time maximize production per unit area; and

(iii) strengthen the national programmes through (a) collaborative research projects and (b) training

Results

Biotic stresses

Diseases

Among the sorghum diseases, grey leaf spot, sooty stripe, leaf anthracnose, and grain mold are the most important in West Africa. Studies by our pathologist on grey leaf spot since 1986 indicated that under natural infection conditions, this disease may have little effect on grain yields in some sorghum genotypes (ICRISAT, 1990).

Among the various techniques tried by the pathologist for augmenting disease symptoms of sooty stripe, the following were useful: dried leaves with abundant sclerotia on soil surface 15 days after sowing (DAS); tied ridges; 0.6 m between rows; spray inoculation with a suspension containing 2×10^4 sclerotia ml^{-1} 30 DAS.

Through multilocation testing, the following lines were identified as sources of stable resistance to leaf anthracnose, grey leaf spot and sooty stripe: 84 S 82, 103-2, and 84 W 838, respectively.

Insect pests

Among insect pests, headbugs (Eurystylus sp) and midge received our attention. Since 1985, we evaluated routinely our breeding and germplasm lines for headbug resistance under natural and artificial infestation conditions using head cages. Our entomologist confirmed the resistance of Mali Sor 84-7 and CSM 388 to headbugs (ICRISAT 1990). In our breeding programme,

we tried to improve our high yielding varieties for headbug resistance. We identified two selections, 87W736 and 87W776, as comparable to Mali Sor 84-7 in resistance and with higher yields.

We also attempted to transfer midge resistance of ICSV 197, into our breeding lines. Two of our selections, 87W726 and 87W718, were resistant and high yielding. In addition, some breeding lines received from ICRISAT Centre with high yield potential also exhibited high levels of resistance to midge. They are PM 14383, PM 14404 and PM 14383-2 (ICRISAT 1990).

Striga

Soil solarization was found to be very effective in controlling Striga. Covering of wet soil for 35 days with a polyethylene sheet reduced Striga emergence significantly and doubled sorghum grain yields - 1.72 t ha^{-1} compared to 0.87 t ha^{-1} for the control (ICRISAT 1990).

We screened about 630 germplasm lines that were identified as low stimulant to S. asiatica of ICRISAT Centre, India, against S. hermonthica. We finally confirmed the resistance of five of these varieties. They are IS 7777, 7739, 6961, 14825 and 14928 (ICRISAT 1988b).

Our major emphasis is to develop integrated striga control packages including resistant varieties and simple agronomic practices. In one of our trials conducted in 1989, a combination of ICSV 1063 BF and 2, 4-D herbicide was found to be the best for controlling striga and increasing grain yields (ICRISAT 1990).

Sorghum improvement

Breeding of long duration varieties (> 120 days to mature).

The objective of this programme is to develop full season varieties adapted to the northern Guinea zone (900 - 1200 mm of annual rainfall). We are improving the Guinea sorghums for yield and caudatum types for resistance to grain mold using population improvement approach. We also evaluated 232 photosensitive West African accessions and selected 12 for use in pedigree breeding programme.

Breeding of medium duration varieties (105 - 120 days to mature).

The objective is to develop high yielding varieties with resistances to major biotic and abiotic factors that reduce yields in the intermediate rainfall zone (700 - 900 mm of annual rainfall) of West Africa. During the last two

years' we identified ICSV 1063 BF and ICSV 1079 BF as most stable and higher yielding (Table 1) through multilocational tests of our advanced lines in Mali and Burkina Faso. Both varieties have acceptable food quality. The on farm tests of ICSV 1063 by the Malian National Programme were successful (Zana SANOGO, 1990) in Mali. Both ICSV 1063 BF and 1079 BF will be tested on the farmers' fields in the rainy season of 1990. These varieties combine acceptable levels of resistance to most of the leaf diseases and resistance to lodging. Other varieties of interest are ICSVs 111, 1089 and 1083.

We continued to diversify our genetic materials through crosses with local guinness varieties, improved resistance sources and other high yielding introductions.

Development of hybrids.

We have a strong hybrid programme based in Kano, Nigeria. Since 1985, we introduced several female and male parents and tested them in several West African locations. The best female parents are: ICS AS 1, 2, 11, 26, 37, 39 and 41 (ICRISAT 1988b). Among the hybrids tested in 1988, ICSH 507 was found to be the highest yielding followed by ICSH 780 (ICRISAT 1989). ICSH 507 is now undergoing agronomy and seed production tests in Nigeria.

Food quality of sorghum

In West Africa most of the sorghum grain is used for human consumption and almost all sorghum production is under rainfed conditions. The improved varieties were found to suffer grain quality deterioration due to attack by grain molds and headbugs. Selection of varieties that suffer less is therefore an important criterion in our sorghum improvement. We evaluated 12 varieties grown in seven locations in Burkina Faso and Mali in 1988 rainy season for the desirable grain quality. The percentage recovery of endosperm after dehulling the grain for 5 minutes using Tangential Abrasing Dehulling Device (TADD) was highest (83%) for the local variety. Among the improved varieties ICSV 16-5 (76%), ICSV 1078 BF (72%) ICSV 1093 BF (71%) and ICSV 1079 BF (70%) had acceptable scores and produced acceptable "tô" (porridge).

Sorghum based intercropping systems

Sorghum/cowpea

The intercropping of cowpea in sorghum is a common practice in West Africa. The local cowpea varieties are indeterminate and spreading and thus limit the density of plants per unit area. The grain and fodder yield of local cowpea varieties were reduced in intercropping and short statured early sorghum varieties like Mali Sor 84-7 were less competitive when intercropped (ICRISAT 1987).

Table 1:

TABLE 1. MEAN GRAIN YIELD OF SELECTED SORGHUM VARIETIES IN MULTILOCATIONAL TRIAL CONDUCTED IN RAINY SEASONS OF 1988 AND 1989 IN MALI AND BURKINA FASO [1]

Cultivars	Samanko (Mali) DOS1[2]	Samanko (Mali) DOS2	Samanko (Mali) LF[3]	Sotuba (Mali)	Tieourala (Mali)	Longorola (Mali)	Cinzana (Mali)	Farako-Ba (Burkina Faso)	Saria (Burkina Faso)	Mean
1988										
ICSV 1079 BF	3.15	2.23	2.36	2.36	1.80	-	2.89	2.55	2.32	2.59
ICSV 1063 BF	2.80	2.65	2.59	1.91	2.27	-	2.32	2.50	3.64	2.59
ICSV 1083 BF	2.26	2.40	2.58	1.61	1.95	-	2.14	2.55	3.31	2.35
Controls										
S-34	2.22	2.40	2.18	1.61	2.59	-	1.83	2.42	3.19	2.31
Local variety	1.84	0.96	1.19	1.00	2.79	-	1.73	1.45	2.25	1.53
SE	0.16	0.18	0.23	0.14	0.29	-	0.17	0.18	0.18	
Trial mean (12)	2.36	2.19	2.18	1.69	1.97	-	2.13	2.31	3.05	
CV %	17	20	26	21	36	-	20	19	15	
1989										
ICSV 1079	3.45	2.27	1.55	-	-	2.68	4.10	2.42	-	2.75
ICSV 1063	2.99	2.38	1.51	-	-	2.35	3.77	2.60	-	2.60
ICSV 1083	3.25	1.74	1.33	-	-	2.16	4.06	2.33	-	2.48
Controls										
S-34	1.94	1.16	1.32	-	-	1.63	2.95	2.63	-	1.94
Local variety	1.34	1.11	1.62	-	-	0.68	2.83	2.57	-	1.69
SE	0.19	0.18	0.22	-	-	0.17	0.17	0.25	-	
Trial mean (12)	2.56	1.49	1.43	-	-	1.77	3.35	2.25	-	
CV %	18	30	38	-	-	24	13	27	-	

1. Randomized-block design with 6 replications, plot size ranged from 7.5 m^2 to 8 m^2 in 1988 and from 7.5 to 15 m^2 in 1989.
2. DOS 1 (First date of sowing) = 1.7. 1988, 24.06. 1989
   DOS 2 (Second date of sowing) = 23.7. 1988, 22.07. 1989
3. Lf = No fertilizers in 1988 and 17 N : 17 P : 17 K in 1989.

The availability of improved erect early cowpea varieties have improved the intercropping situation. The density of such varieties like KN - 1 could be increased to 10 plants m^{-2} without reducing sorghum grain yields. The results indicated that the yield levels of the traditional sorghum/cowpea system could be improved by up to 3 t ha^{-1} of sorghum and 0.5 t ha^{-1} of cowpea by using improved cultivars and better management (ICRISAT 1988c). These studies did not look at optimum date of planting of cowpea and spatial arrangements in relation to sorghum which might further improve the efficiency of the system. The results we obtained by sowing cowpea at different times (same time as sorghum, 10, 20, and 90 days after sowing of sorghum) and three spatial arrangements (1:1, 1:2 and 2:2 of sorghum and cowpea) were interesting (Table 2). The delayed sowing of cowpea at least 20 days after sorghum (DAS) increased sorghum grain yields significantly compared to simultaneous sowing. Though sowing cowpeas 90 DAS had higher sorghum yields it was not significantly higher compared to sowing of cowpea 20 DAS. Among the spatial arrangements, alternate pairs of rows (2S : 2C) of sorghum (Mali sor 84-1) and cowpea (TN 8863) were more profitable to sorghum production compared to other arrangements.

TABLE 2: YIELD OF SORGHUM AS AFFECTED BY COWPEA SOWING DATE AND SPATIAL ARRANGEMENTS AT SAMANKO, MALI, RAINY SEASON 1989.

Cowpea Sowing dates	Spatial arrangement			Mean
	IS : IC	IS : 2C	2S : 2C	
	t/ha			
Simultaneous sowing	1.15	1.18	1.63	1.32
10 days after sorghum	1.23	1.65	1.90	1.59
20 days after sorghum	2.01	1.81	2.17	1.99
90 days after sorghum	2.01	2.11	2.48	2.20
Mean	1.60	1.69	2.04	1.78

SE for comparing cowpea sowing dates = 0.094
SE for comparing spatial arrangement = 0.081
CV (%) 22

Randomized block design with two factors, 6 replications, Plot size = 18 m^2.

Sorghum/groundnut

Groundnut is an important cash crop for the farmers in West Africa. It is often intercropped with sorghum. Previous intercropping results indicated that delayed planting of sorghum by four weeks resulted in higher economic value in terms of increasing groundnut yields compared to simultaneous planting

but sorghum yields decreased significantly (ICRISAT 1987, 1988) because of its poor establishment. Identification of sorghum varieties which are able to establish well when planted late in an already established groundnut crop will further increase the efficiency of the system. The Nitrogen fertilizers exhibited significant effects in increasing sorghum yields. The recent results in Mali indicate that the simultaneous planting of sorghum and groundnut in 1:4 ratio and application of 50 N and 65 P to both crops before sowing is beneficial (ICRISAT 1990).

Weed control in intercrops

The general observation is that in intercrops with legumes, weed problems are less because of rapid ground cover by the legumes. In our experiments to quantify the effects of intercrops on weeds and grain yields of the intercrops we found that sorghum/cowpea depressed the weed emergence more effectively than sorghum/groundnut system (ICRISAT 1990). Mean fresh weights of weeds at 70 DAS were 1.81 t ha^{-1} and 2.33 t ha^{-1} in sorghum and groundnut sole crops compared to 1.47 and 1.10 t ha^{-1} in sorghum/groundnut and sorghum/cowpea intercrops. Consequently, only two weedings were required (20 and 40 days) in intercrops compared to three (20, 40 and 70 DAS) in sorghum sole crops, thus decreasing labor costs by about 10%.

Future prospects

i. We will continue to improve on the high yielding varieties like ICSVs 1063, 1079, 111 and Naga White (from Ghana) for resistance to headbugs, midge, grain mold and Striga.

ii. More emphasis will be given to the improvement of full season local guinea sorghums for grain yield through population improvement approach.

iii. Some of our varieties like ICSV 1063 and 1079 are in high demand in Mali, ICSV 1063 and Mali Sor 84-1 in Cote-d'Ivoire; we will work closely with these NARS to ensure that these varieties become available to farmers in these countries.

iv. Development and demonstration to NARS of Improved integrated Striga control packages.

v. Testing of improved varieties and cropping systems in some selected villages in Mali in collaboration with the national scientists.

References

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Centre. 1987. ICRISAT West African Programmes annual report 1986. ICRISAT/Mali cooperative program. Pages 149-160. BP 12404, Niamey, Niger. ICRISAT Sahelian Centre.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1988a. Medium-term programme plans and funding requirement 1989-1993. Patancheru, A.P. 502324, India: ICRISAT.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1988b. Annual Report 1987. Sorghum. Pages 24-72. Patancheru, A.P. 502324, India : ICRISAT.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). Sahelian Centre. 1988c. ICRISAT West African Programmes annual report 1987. ICRISAT/Mali cooperative programme. Pages 131-147. BP 12404, Niamey, Niger: ICRISAT Sahelian Centre.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Annual Report 1988. Sorghum. Pages 3-20. Patancheru, A.P. 502324, India : ICRISAT.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Annual Report 1989. Patancheru, A.P. 502324, India : ICRISAT.

FAO (Food and Agricultural Organization). 1988. Structure et Caracteristiques de I'Economie Mondiale du sorgho, CCP : GR 88/4, Aout 1988. FAO, Rome, Italy.

Zana Sanogo (1990). Personal communication.

Discussion

T. DEL GUIDICE

As you mentioned in your presentation you have started with an On-Farm Experimentation programme. Which are the methods you are using and have you included other research institutions in that programme?

P. SALEZ, ICRISAT

Since we have a regional mandate, we can't work directly with national extension agencies. So we go through national Malian research, get a collaborative project with them, and then we can contact extension agencies (especially cotton agencies like CMDT).

SOME ASPECTS OF CROPPING SYSTEMS RESEARCH IN THE SAVANNA ZONE OF NORTHERN GHANA

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Nyankpala Agricultural Experiment Station

Summary

Increasing population pressure leads to scarcity of land which brings about continuous cultivation, causing rapid soil deterioration and loss of productivity. Improved cropping systems, among other measures of land use improvement (manure, agroforestry, liming etc.), might help to overcome these problems. Previous crop rotation trials indicated an advantage of crop rotation over intercropping for the maintenance of high productivity of savanna soils. The best preceding crops for cereals were: groundnut (G) > yam > maize > G/maize.

In a follow-up trial (started in 1985) which combined intercropping and crop rotation with various new crops such as soybean (Soy), cowpea (C) and cassava (Ca), the residual value of the preceding crops for maize and maize/sorghum intercrop (1:1 ratio), was assessed.

The best preceding crops to maize were: C > G > Ca > Soy. Maize and maize/sorghum reduced maize yields to 1/3 of the level obtained from the best preceding crops.

Using Land Equivalent Ratios (LER), intercropping maize and legumes was disadvantageous, whereas maize/cassava showed LER values greater than 1 (1.56; 1.27; 1.05 for 1986, 1987 and 1988, respectively), followed by maize/sorghum and maize/cowpea during the same period (comparative figures for maize/sorghum and maize/cowpea were 1.14; 1.22; 1.00; and 1.03; 1.07; 0.91, respectively for the three years).

Groundnut yields were lower when intercropped with maize and maize/sorghum than soybean and cowpea in identical systems. Maize yields were also lower when intercropped with soybean, cowpea, groundnut and cassava. Promising intercrop combinations were maize/sorghum and maize/cassava.

The results indicate that several crop sequence combinations could be utilized for an improved land use for adoption by farmers in the savanna zone of Northern Ghana.

Introduction

Intercropping plays an important role in the food production systems of many tropical countries where small-scale farms and labour intensive operations predominate (Willey, 1979a). Given the socio-economic conditions of most farmers, and the wide variability in rainfall in the savanna region,

intercropping is still recognized as a viable strategy for spreading the risks of crop failure and the labour demands for the critical operations of sowing, early weeding and harvesting. In Australia, Ofori and Stern (1986) found significant differences between intercropped maize, intercropped cowpea and the sole crops and attributed the differences to competition for nitrogen by the component crops. This view is supported by Andrews (1972) and Wahua (1983). In Uganda, Willey and Osiru (1972) observed that maize had stronger competitive ability than beans (Phaseolus vulgaris). The biggest advantage of intercropping usually results from the complementary use of growth resources over time and space. The combined intercrop canopy or root systems may make greater and/or more efficient use of light, water and nutrients than the component sole crops (Natarajan and Willey, 1980). The success of intercropping vis-a-vis sole cropping (rotation) will, however, depend on how existing agronomic practices can be manipulated to improve the land-use efficiency of various intercrop systems.

Previous crop sequence trials (Schmidt and Frey, 1986) had indicated a great advantage of crop rotation for the maintenance of a high productivity of Savanna soils. While most intercropping systems have been concentrated on cereal-legume systems, this paper compares cereal-legume systems with cereal-non-legumes in a maize based system. A few selected crops (soybean, sorghum, groundnuts, cassava and cowpea) were used as intercropping partners together with maize. These different intercroppings were compared with alternative cropping systems as monoculture and rotation. The interest was to assess the compatibility of the component crops in the intercrop. Using beneficial effects of rotation and intercropping, cereal-cereal and cereal-non-cereal combinations in a rotation were also investigated.

Materials and methods

This experiment was sited at Nyankpala under the Tolon-Tingoli (Chromic Luvisol-FAO) series of soils under rainfed conditions.

The intercropping partners of maize were cowpea, soybean, sorghum, groundnut, and cassava. In one particular case, however, every other maize plant in a row was re- placed by a sorghum plant. The crop combinations were replicated five times in a randomized complete block. Sole cropping of maize, the mixture maize/sorghum and the legumes/non-legumes mixtures were planted on plots measur- ing 10 m x 6 m. The different sole crops were rotated annually except for the maize/sorghum intercrop replacing sole maize. This was rotated with sole crop of groundnuts. The intercrop was environment. In 1985 and 1986 intercropping was practiced in the form of alternating rows. However, in 1987 intra-row cropping was introduced to reduce the cumulative effects of intercropping partners. This lay-out

seemed to be the best possible simulation of farmers' practice. The distance between the two intercropping components was 10 cm. The crop combinations, spacing and densities are indicated in Table 1.

TABLE 1: CROP COMBINATIONS, SPACING AND DENSITIES

Combination	Spacing (cm)	Density (pl/ha)
1) Maize and sorghum		
as sole crop	75 x 60	44.444
as intercrop*	75 x 60	22.222
2) Groundnut		
as sole crop	75 x 24	111.111
as intercrop*	75 x 24	55.555
3) Cowpea		
as sole crop	75 x 30	88.888
as intercrop*	75 x 30	44.444
4) Soybean		
as sole crop	75 x 12	222.222
as intercrop*	75 x 12	111.111

* (1 row each)

Where the maize/sorghum intercrop replaced sole maize as a partner of groundnut, every second maize plant within the same row was replaced by sorghum.

Sole cassava was planted at a distance of 100 cm x 100 cm (10,000 plants per hectare). In the case of cassava/maize intercropping, every second cassava plant was replaced by 4 or 5 maize plants in alternating replacement positions. The number of cassava plants was thus 5.000/ha and maize 22.000 plants/ha.

Cowpeas were sprayed three times with insecticide (Decis and Thiodan at 1.2 g a.i./ha). 26 kg P/ha as single superphosphate and 50 kg/ha of potassium as potassium sulphate were applied before plant establishment. All non-leguminous plants received 40 kg N/ha as ammonium sulphate. Equivalent quantities of N per plant were applied to the hills of the non-leguminous plants.

Results and discussion

The best performance of sole crop maize was observed when groundnut, cowpea and cassava were used as preceding crops. This confirms the report by Schmidt and Frey (1986) where these crops (excluding cassava) did not only fix nitrogen, but also reduced the infestation level of *Striga*. Sole maize performed best (5.13 t/ha compared with a 3 year average of 4.21 t/ha) after groundnut followed by cowpea (av. 4.18 t/ha) and cassava (av. 4.12 t/ha). Sorghum was the worst preceding crop for maize with an annual average yield of 2.63 t/ha (Table 2).

TABLE 2: YIELDS (A) OF VARIOUS INTERCROPPING COMBINATIONS (NYANKPALA 1986-89)

Crops (b)	Cereal yield (t/ha) '86	'87	'88	Non-cereal yield (t/ha) '86	'87	'88
M	5.13	4.10	3.46			
G				G 1.18	0.93	1.37
MG	2.68	2.45	1.09	G 0.35	0.29	0.56
M	4.94	3.80	3.82			
C				C 1.84	0.33	1.32
MC	2.96	2.25	1.51	C 0.79	0.16	0.67
M	4.94	3.91	3.52			
Ca				Ca 10.48	12.75	13.65
MCa	2.71	2.71	1.45	Ca 10.57	7.38	8.79
M	4.82	3.69	2.99			
Soy				Soy 1.32	1.06	1.74
MSoy	1.95	1.93	0.87	Soy 0.81	0.55	0.85
MS (f)	4.56	3.29	2.50			
G				G 1.14	0.92	1.31
MSG (f)	1.71	1.69	1.29	G 0.43	0.21	0.39
M	3.92	2.75	1.22			
S	0.98	1.11	1.45			
M(S) (c)	3.19	1.17	0.58			
S(M) (c)	0.43	0.21	0.39			
LSD (P=5%)	0.40d					
	0.51e					

(a) Grain yields at 12% H_2O, cassava: fresh weight.
(b) M = maize; G = groundnut; C = cowpea; Soy = soybean; Ca = cassava S = sorghum.
(c) M(S) shows only maize yields. S(M) shows only sorghum yields.
(d) For comparison of sole maize only.
(e) For comparison of intercropped maize only.
(f) Added maize and sorghum yields.

Maize intercropped with legumes showed a disappointing performance as compared with sole cropped maize. This is especially true if intercropped with soybean and cowpea. This can be attributed to the similar growth pattern of maize, soybean and groundnut, peak demands of water and nutrients for legumes occurred at the same time as for maize as the dominant component of the intercrop system (Andrews, 1982; Wahua, 1983; Ofori & Stern, 1986). Using Land Equivalent Ratios (LER) the best intercrops, in descending order, with LERs more than 1 were maize/cassava (1.56; 1.27; 1.05), maize/sorghum after groundnuts (1.14; 1.22; 1.00) and maize/cowpea (1.03; 1.07; 0.91) (Table 3).

TABLE 3. COMPARISON OF VARIOUS SOLE CROPS WITH INTER-CROPPING COMBINATIONS USING LAND EQUIVALENT RATIOS (LER) (NYANKPALA 1986-88)

Crops	Land equivalent ratios (LER) 1986	1987	1988
M	0.52	0.60	0.32
G	0.30	0.31	0.41
M+G	0.82	0.91	0.73
M	0.60	0.59	0.40
C	0.43	0.48	0.51
M+C	1.03	1.07	0.91
M	0.40	0.52	0.29
Soy	0.61	0.52	0.49
M+Soy	1.01	1.04	0.78
M	0.55	0.69	0.41
Ca	1.01	0.58	0.64
M+Ca	1.56	1.27	1.05
M	0.81	0.43	0.48
S	0.33	0.79	0.52
M+S	1.14	1.22	1.00
M:S = 1:1	0.38	0.51	0.52
G	0.38	0.23	0.30
MS+G	0.76	0.74	0.82

M = maize; G = groundnut; C = cowpea; Soy = soybean;
Ca = cassava; S = sorghum
LER = Land Equivalent Ratio

Conclusions

The best intercropping partners of maize were cassava and sorghum. The beneficial effects of rotation cannot be over-emphasized, with the residual effect of the preceding crop(s) determining the productivity of the succeeding crop(s). This experiment will be continued in order to assess long term effects of:

(a) permanent intercropping vs permanent rotation and
(b) intercropping vs rotation in dry and wet years.

Productivity of intercropping can be increased not only through the use of compatible intercropping components but also through the use of appropriate agronomic practices, including crop rotation in order to improve the land-use-efficiency of various intercrop systems.

References

Andrew, D. J., (1972). Intercropping with sorghum in Nigeria. Exp. Agric., 8: 139pp

Natarajan, M and R. W. Willey, (1980). Sorghum Pigeon pea intercropping and the effects of plants population density. 2. Resource Use. J. Agric Sci., Camb., 95: 59pp

Schmidt, G. and E. Frey, (1986). Nyankpala Agric. Experiment Station Annual Report 1986/87. 25pp

Wahua, T. A. T., (1983). Nutrient uptake by intercropped maize and cowpea and a concept of nutrient supplementation index (NSI). Exp. Agric., 19: 263pp

Willey, R. W., (1979). Intercropping, its importance and research needs. 1. Competition and yield advantages. Field Crops Abstracts, 32: 1pp

Willey, R. W. and Osiru, D. S. O., (1972). Studies on mixtures of maize and beans (Phaseolus vulgaris) with particular references to plant population. J. Agric. Sci. Camb., 79: 517pp

Discussion

H.K. DAPAAH

Legumes were good preceding crops but in the intercrops they were not as good as cassava and sorghum. Could you give any explanation or reasons for this?

H. RUDAT

If you put legumes and cereals with similar growth cycles together, both are likely to compete in a similar way for factors like water, nutrients, but also light, oxygen, etc. The experiment was not meant to look after that.
Ways out of these problems are different growth cycles of crops, relay cropping, rotation, etc.

TWUMASI-AFRIYE

Yam has been shown all along to be a good preceding crop either alone or in combination with legume, what is being done with such finding which has been determined since the early years?

H. RUDAT

As preceding crop for maize, yam ranged 3rd. Better preceding ones were GN and M/GN. For sorghum and groundnut yam ranged 3rd again; for yam, yam ranged 4th.
All our information goes to Extension Service and others who are in need of informations. For cleared land farmers use yam as 1st crop. To convince them at this stage to use yam again in the 3rd or 4th year it might be difficult.

D.K. ACQUAYE

From soil nutrients point of view, maize is more demanding than sorghum. Could you explain why sorghum proved to be the worst preceding crop? was there any intercropping of sorghum and groundnut or as a preceding crop for groundnut? If yes, what was the effect of sorghum?

H. RUDAT

Not only maize but also sorghum is a very demanding crop although over a longer growing period than maize (long cycle sorghum). Biomass production of sorghum is ca. 15-20 t/ha in comparison to maize with 6-7 t/ha. In both experiments 1981-86 and 1985 (on-going) there was intercropping of maize-groundnut and maize - sorghum - groundnut.
Sorghum as preceding crop for groundnut over 5 years gave 1.1 t/ha of shelled groundnut. For maize (M), M/GN, GN, and Yam, the figures were 1.22, 1.34, 1.31 and 1.25 t/ha, respectively.

STUDIES ON MAIZE AND KENAF INTERCROPPING

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Abstract

Commercial cultivation of bast fibres as sole crops is not popular in Ghana especially in the Northern Savanna Zone, since farmers give priority attention to their food crops. However, some bast fibre crops (roselle and kenaf) are sporadically intercropped with maize, millet, sorghum and yam fields primarily as vegetables and as source of fibre.

By incorporating the cultivation of bast fibres into the normal cropping practices, it is hoped that farmers may derive additional benefits from the farming operations.

The present study was undertaken at Nyankpala in the Northern Savanna Zone to find out how best kenaf could be arranged as an intercrop with maize, to give high yield per unit area.

The experimental design was a randomised complete block with four replications. The treatments were seven arrangements (sole maize; sole kenaf; 1M: 1K; 1M 2K; 2M 1K; 2M: 2K and Intra-row.

Generally, the crop mixtures gave greater yield advantages but the best yield advantage was given by the Intra-row cropping maize and kenaf intercropping.

Introduction

Intercropping is an age-old traditional system of agriculture in West Africa. In Ghana, almost every peasant farmer practices intercropping in one form or another. In the cocoa growing areas, young cocoa plants are intercropped with plantain, cocoyam and cassava. Vegetables like pepper, tomato, garden eggs and okro are also intercropped with food crops. In the Northern and Upper Regions of Ghana, legumes such as cowpea, groundnuts and bambara beans are intercropped with sorghum, millet and maize.

Evidence for higher yields from mixtures have been reported from experiments carried out elsewhere. Singh et al, (1987) reported that inter-crops gave additional yields and increased the net returns. Koli, (1975) working on pure cropping and mixed cropping in Ghana reported that, among the mixed cropping treatments, inter-row cropping appeared to be the best in terms of yield and cash return.

Norman (1972) showed that in Nigeria variability in annual returns from crop mixtures was less than that from sole crops. Norman also collected data which demonstrated that labour was more uniformly used throughout the season under mixed cropping.

Commercial cultivation of bast fibres as monocrops is not popular in Ghana especially in the Northern Savanna Zone, since the farmers give priority attention to their food crops. However, roselle and kenaf are sporadically intercropped with maize, millet, sorghum and yam fields, primarily as vegetables in the Northern and Upper Regions of the country.

By incorporating the cultivation of bast fibres into the normal cropping practices, it is hoped that additional benefits may be derived from the farming operations.

The present study was undertaken at Nyankpala in Northern Ghana to find out how best maize can be arranged as an intercrop with kenaf, to give high yield per unit area.

Materials and methods

Seeds of kenaf, variety 2032 and maize, variety Dobidi, were used. The kenaf seeds were sown at spaces of 25 cm between rows and 5 cm within rows.

Three seeds each of maize and kenaf were sown per hole on 3.6 m by 4.5 m plots. Both the maize and the kenaf seedlings were thinned to two per stand three weeks after emergence.

A randomised complete block design was used. There were seven treatments with four replications.

The treatments were as follows (see following designs):

Sole maize

sole kenaf

1M: 1K - 1 row of maize: 1 row of kenaf

1M: 2K - 1 row of maize: 2 rows of kenaf

2M: 1K - 2 rows of maize: 1 row of kenaf

2M: 2K - 2 rows of maize: 2 rows of kenaf

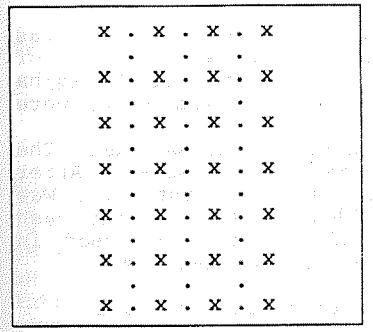
Intra - row cropping

(M: maize; K: kenaf)

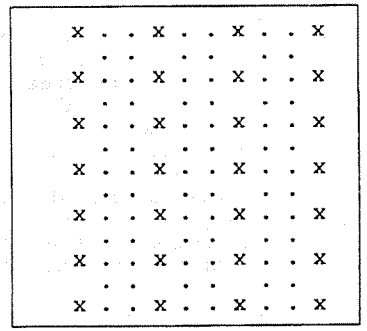
These arrangements gave different kenaf plant populations while the maize population remained constant. On per hectare basis, the sole maize treatment gave 44,444 plants and the sole kenaf gave 1,555,555 plants. The one row of maize and one row of kenaf gave 333,333 plants of kenaf. The one row of maize and two rows of kenaf gave 666,666 plants of kenaf; the two rows of maize and one row of kenaf gave 111,111, plants of kenaf, while two rows of maize and two rows of kenaf gave 222,222 plants of

MAIZE - KENAF MIXED CROPPINGS

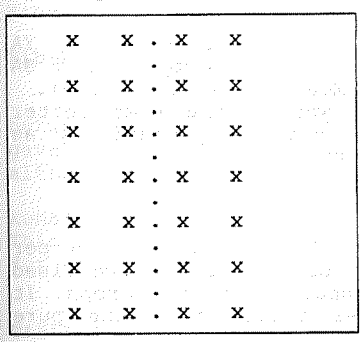
1M : 1K



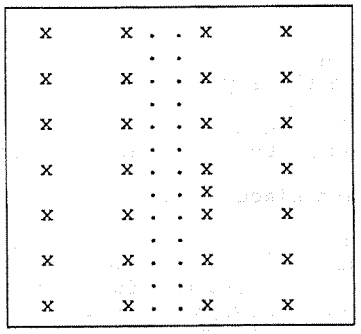
1M : 2K



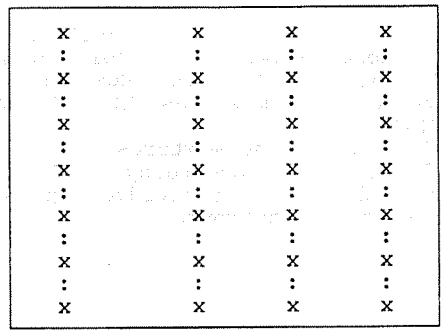
2M : 1K



2M : 2K



INTRA - ROW



kenaf. The intra-row gave 355,555 kenaf plants.

The trial was conducted at Nyankpala in the Northern Savanna Zone of Ghana in 1989. Planting of seeds started with the onset of rains.

At planting, a compound fertilizer (NPK) 20:20:0 was broadcast on the plots at the rate of 100 kg/ha. Sulphate of Ammonia was applied as side dressing at the rate of 50 kg/ha when plants were six weeks old. Both the kenaf and maize were harvested at the same time.

At harvest, the maize cobs were shelled and weighed. The harvested kenaf stalks were bundled rested in water. After resting, they were washed, sun dried and the resultant fibre was weighed. The yields per plot were recorded and the current cash values of the two crops at the time of harvest were used in evaluating and analysing the monetary returns per hectare.

The Land Equivalent Ratio (LER) was calculated for all the crop mixtures. Using simple notation, the LER was calculated as $LER = LA + LB = \frac{YA}{SA} + \frac{YB}{SB}$

Where LA and LB are the LERS for the individual crops, YA and YB are the individual crop yields in intercropping and SA and SB are their yields as sole crops, (Mead and Willey, 1980).

Within each column means not followed by the same letter are significantly different at the 5% level of probability as determined by Duncan's Multiple Range Test.

Results and Discussions

Results of the trial are given in Table 1 and 2. On per hectare basis each crop gave higher yields when it was realised that the pure culture afforded correct spacing for the crops. It was therefore evident to obtain higher yields from the pure stands than in the mixed cropping.

Grain yield

The statistical analysis show significant (P=0.05) differences in grain yield between the sole maize and the mixtures 1M: 2K; 1M: 2K; and 2M: 1K. However, differences between the sole maize and the mixtures 2M: 2K and intra-row were not significant (P=0.05).

The best grain yield among the mixtures occurred at higher plant population levels (2M: 2K). According to De Wit, (1960), this situation occurs when the individual plants utilize slightly different parts of the environment.

TABLE 1. YIELDS AND CASH VALUES OF MAIZE AND KENAF FIBRE NYANKPALA, 1988.

Treatments	Maize		Kenaf fibre		Total Cash value of Maize and Fibre
	Yield (kg/ha)	Cash value ¢	Yield (kg/ha)	Cash value ¢	
Sole	4680.70 B	208066.96	796.73 B	114187.34	
1M :1K	2708.33 CD	120907.58	464.23 BC	66533.44	187441.02
1M :2K	2812.51 CD	125558.48	350.69 BC	50260.89	175819.37
2M :1K	2968.75 CD	132533.48	265.80 BC	38094.45	170627.93
2M :2K	3585.15 BC	160051.33	255.56 BC	36626.85	196678.18
Intra	3295.09 BC	147102.23	426.60 BC	61140.31	208242.54

Prices : Maize = ¢5,000.00 per 100 kg (Ghana Food Distribution Corporation)
Fibre = ¢143,320.00 per ton (GIGOC Fibre Products, Kumasi)

Fibre yield

There were significant (P=0.05) differences in fibre yield between the sole kenaf and the mixtures. Of the mixtures, 1M: 1K gave the highest fibre yield while 1M: 2K produced the lowest, although the difference was not significant (P=0.05).

Yields from 2 rows of maize to either one row or 2 rows of kenaf were relatively lower as compared to the other mixtures. This suggests some sort of competition among the crop species for either light or soil nutrients.

TABLE 2: LAND EQUIVALENT RATIO (LER) OF MAIZE/KENAF INTERCROPPING NYANKPALA, 1989.

Crops	1M : 1K	1M : 2K	2M : 1K	2M : 2K	Intra
Maize	0.58	0.61	0.64	0.73	0.71
Kenaf	0.58	0.44	0.33	0.32	0.53
Total	1.16	1.05	0.97	0.05	1.24

Cash return on per hectare basis

It was noticed generally that the crop mixtures gave greater yield advantages in terms of land equivalent ratio (LER) except 2M : 1K.

In terms of monetary value, all the crop mixtures gave better returns than the pure stand of kenaf. The intra-row cropping had higher total productivity and cash return than maize and kenaf in pure stands.

References

De Wit, C.T. (1960). On competition Versl. Landbouwk Onderz 66:8.

Koli, S.E. (1975). Pure cropping and mixed cropping of maize and groundnuts in Ghana. Ghana Jnl. Agric. Sci. 8:23-30

Mead, R. and R.W. Willey (1980). The concept of a land equivalent ratio and advantages in yields from intercropping. Exp. Agric 16: 217-218.

Norman, D.W. (1972). An economic survey of three villages in Zaria province. Input - Output relationships. Ahmadu Bello University, Samaru, Nigeria.

Singh, Y.P., R.P. Sharma, (1987). Intercropping in rabi maize for higher production. Seeds and Farms 13 (12) 12-14.

Discussion

E.A. ADDISON

Rotation has been shown to give better results than intercropping. Why then are you limiting your work to inter-cropping? What use did you make of the cropping systems research efforts at NAES in formulating your project?

A.K. ASANTE

(1) My work is not limited to intercropping only. A four-year crop rotation has been planned upon the advice of the Project Manager and it will take off this year.

(2) Proposals for every year are presented during an In-House Review for approval and adoption. All my work trials are therefore accepted by NAES before implementation.

A. ZAKARIAH

Did you consider input costs before concluding that the intra-row cropping gave the heighest productivity?

A.K. ASANTE

Yes. The same man-days, fertilizer etc. were applied over the experiment.

MAIZE AND MILLET YIELDS AS INFLUENCED BY TILLAGE SYSTEMS AND NITROGEN LEVELS

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Abstract

Moisture availability and low soil productivity are two major limiting factors to crop production in northern Ghana. Tillage is a practice that increases plant avai-lable water and improves soil productivity. The study was conducted in 1988 and 1989 to determine the grain yield response of maize (Zea mays L.) and millet (Pennisetum americanum) to tillage systems and N rates. In 1988, the tillage systems were tractor, hoe and no tillage; and the N rates were, 0, 75 and 150 kg N/ha. In 1989, bullock treatment was included; the N rates were 0, 60 and 120 kg N/ha. Maize was planted at Nyankpala and Damongo, and millet was planted at Manga/Bawku. In the first year, tillage effect on maize yield was not significant at Nyankpala; tillage effect on yield at Damongo and Manga was significant. The highest and lowest yields were obtained under tractor and no tillage respectively. In 1988, N effect on maize yield was significant at Nyankpala and Damongo with grain yields highest and lowest at 150 and 0 kg N/ha respectively; millet did not respond to N. In 1989, tillage effect on grain yield was significant at all locations, but trends were not like in 1988; bullock tillage, however, resulted in significantly higher grain yields than tractor tillage at all locations. The response of crops to N was the same as in 1988. Except for Damongo in 1988, there was no tillage x N interaction, indicating that N recommendations could be similar for the tillage systems. The data suggest promoting bullock use in the Northern Region of Ghana while more research is needed in conservation tillage.

Introduction

In northern Ghana moisture shortages during part of the growing season and the generally low soil productivity may be considered the two most important agronomic factors limiting productivity. Tillage, the method of land preparation for planting is aimed at preparing a suitable seed bed, eliminating weed competition and improvement of the physical condition of the soil (Martin et al, 1976). The best system of tillage is the one that accomplishes these objectives with the least expenditure of labour and power. In North America in particular, there is a shift in tillage systems to conservation tillage because of the increased availability of subsoil water, reduced runoff, soil erosion and energy (Phillips, 1984; Blevins, 1984; Frey, 1984).

Conservation tillage is a system of managing crop residue on the soil surface with minimum or no tillage, (Unger and McCalla, 1980). No tillage is defined as the introduction of seed into unploughed soil in narrow slots, trenches or bands of sufficient width and depth for seed coverage and soil contact (Phillips, 1984). No tillage is not commonly practised in northern Ghana; however, it is the general practice in the forest areas of Ghana where the planting material (seed, stem, etc) is planted into an untilled soil after 'field preparation' (slashing and burning).

Several studies comparing tillage systems have shown no tillage yields to be greater than conventional tillage (Anderson, 1990; Wagger and Denton, 1989). The elimination of tillage from crop production systems however affects soil processes that influence N status of soil (Jackson et al, 1983). Tillage effects on grain yield are often manifested at low fertilizer N rates, but decline as N rate increase (Meisinger et al, 1985) and broadcasting fertilizer N in no tillage plots resulted in lower yields than when broadcast onto conventional plots (Locke and Hons, 1988).

Lal (1981) indicated that regions like northern Ghana in the tropics characterised by (a) high intensity rainstorms with thunder showers in the beginning of the rainy season after a prolonged dry spell; (b) where there are two or three periods of seven to ten rainless days during the rainy season, (c) where the precipitation is unpredictable and annual rainfall exceeds 500 mm are favoured in the use of no tillage farming system.

The objectives of this study were to determine (a) the grain yield response of maize and millet when grown under different tillage methods and (b) the nitrogen requirements of maize and millet grown under the tillage methods.

Materials and methods

The experiment was conducted at Nyankpala and Damongo in the Guinea Savanna Zone and at Manga/Bawku in the Sudan Savanna Zone of Ghana. The experimental design was a split plot factorial with tillage system being the main plots and N fertilizer rate assigned to the subplots. There were four replications.

1988: Three tillage systems were compared, (i) hoe, (ii) tractor disc plough and harrow, and (iii) no tillage. The N rates were 0, 75 and 150 kg N/ha. The hoe till was to a depth of about 7.5 cm, and the tractor plough depths were about 20 cm and 15 cm at Nyankpala and Damongo respec-tively. At Manga, there was no need to plough because of the looseness of the soil so the field was harrowed twice to a depth of 15 cm. In the no tillage plots vegetation was killed with either the nonselective contact herbicide 'gramoxone'-paraquat (1, 1'-dimethyl-4, 4'-bipyridinium ion) or with the nonselective systemic herbicide, 'round up'-glyphosate, N-(phosphonomethyl) glycine. The gramoxone and roundup were applied at the rate of 2.0 l and 1.5 l per hectare respectively.

At Nyankpala and Damongo, maize varieties, 'Safita' (early maturing) and 'Dobidi' (late maturing) were planted on 7th July and 24th June respectively. At Manga, late millet was planted on June 22. Plots were seven rows, 30 m long (main plot) and 10 m long (sub plot). Interrow spacing was 0.75 m and intra-row spacing was 0.27 m. Seeding was two seeds per hole and later it was thinned compensatorily to one plant per stand (50,000 plants/ha). The N source was urea applied in split application at planting and at 4-6 weeks after planting. Phosphorus (triple superphosphate) and K (KCl) were applied to all plots at 50 kg P and 50 kg K per hectare. Fertilizer was broadcast at planting and incorporated into the soil except in the no tillage plots where the fertilizer was left on the soil surface. The second N application was by furrow banding in all plots. Weeds were hoed in the hoe and tractor tilled plots. Weed control in the no tillage was achieved by application of primagram (a.i. 250 g/l metolochlor, 235 g/l atrazine and 10 g/l atrazine related compounds) at 4.0 l/ha after planting and later, weeds were controlled with paraquat. The three middle rows were harvested for yield determination.

1989: New fields were selected with the inclusion of bullock tillage as a treatment. The N rates were 0, 60 and 120 kg N/ha. The sources of fertilizer were, N (ammonium sulphate), P (Single superphosphate) and K (K_2SO_4). The P and K were applied at 25 kg P/K per hectare. The maize variety, 'Dorke' (early maturity) was planted at Nyankpala, and the variety, 'Okomasa' (late maturity was planted at Damongo. The experimental design and all other cultural practices were as those described for 1988.

Results and discussion

The two years, 1988 and 1989 were unusually wet years. In 1989, rainfall was about 150% the normal. At Damongo where germination count was taken, crop establishment was lowest under no tillage. In 1988, rodent attack to maize seedlings was also observed in the no tillage plots at Damongo.

Results for the two years are presented separately because,

(i) the number of main plot treatments differed for the two years,

(ii) the N rates were different for the years.

There was also no combined across site analyses for maize yield data because maize varieties of different maturities were planted at Nyankpala and Damongo. The results are considered preliminary since the benefits of no tillage are realised after several years.

The effect of tillage and N rate on maize and millet grain yield at Nyankpala, Damongo and Manga/Bawku for 1988 and 1989 are given in Tables 1 and 2.

NYANKPALA (a) 1988: Maize grain yield was very low relative to maize and millet yields at Damongo and Manga (Table 1). Tillage effect on grain yield was not significant. Nitrogen effect on grain yield was significant with the highest grain yield obtained when 150 kg N/ha was applied and the lowest yield was with 0 kg N/ha.
There was no significant tillage x N interaction. Grain yield ranged from 128 kg/ha (hoe, 0 kg N/ha) to 1547 kg/ha (tractor, 150 kg N/ha) (Table 1).

1989 (b): Both tillage and N effects on grain yield were significant. There was no significant tillage x N interaction for grain yield. This means N recommendations could be the same for the tillage systems. Averaged across N treatments, the highest grain yield was under hoe, followed by no tillage, bullock and tractor. The hoe, no tillage and bullock tillage yields did not differ statistically (0.05), but all three yields were signi-ficantly higher than the tractor yield. Like in 1988, maize grain yield in 1989 was significantly influenced by N (Table 2).

DAMONGO Maize grain yield was affected by tillage and N in both years.

(a) 1988: Averaged across N treatments, the highest grain yield of 6339 kg/ha was obtained under tractor, followed by hoe (4688 kg/ha) and no tillage (3162 kg/ha). When averaged over tillage treatments, maize responded to N in excess of 75 kg N/ha (Table 1). There was a significant tillage x N interaction. Under no tillage and tractor, grain yield increased linearly with increasing rates of N while under hoe, yield increased from 0 to 75 kg N/ha and levelled.

1989: When averaged over N treatments maize yields in decreasing order were bullock, tractor, hoe and no tillage. There was however no yield difference between the hoe and no tillage (Table 2). The generally lower yields under no tillage at Damongo could be due to excessive leaching of applied fertilizer, particularly the N which was left on the soil surface at the first application. Locke and Hons (1988) also observed broadcasting fertilizer may have led to lower yields on no tillage plots in their studies. When averaged over tillage treatments, maize yielded significantly higher at 120 kg N/ha than at 60 kg/ha. There was no significant tillage x N interaction.

MANGA: In both years there was a significant tillage effect on grain yield (Tables 1 and 2). Averaged across N treatments the

highest and lowest yields were under tractor and no tillage in 1988; in 1989, the order of grain yield was bullock, tractor, no tillage and hoe (Tables 1 and 2). In both years, grain yield of the millet variety used was not significantly affected by N. The non-response to N could be due to the low acidic soils of the fields.

TABLE 1: EFFECT OF TILLAGE AND N ON MAIZE AND MILLET GRAIN YIELD AT NYANKPALA, DAMONGO AND MANGA, 1988

Tillage systems	Yield of Maize		Yield of Millet
	Nyankpala+	Damongo++	Manga
	kg/ha		
	0 kg N/ha		
Hoe	128	2880	830
Tractor	343	5000	1228
No tillage	145	2258	533
N means	205	3369	863
	75 kg N/ha		
Hoe 8	257	5389	1244
Tractor	553	6395	1343
No tillage	713	3259	641
N means	508	5014	1076
	150 kg N/ha		
Hoe	414	5827	1231
Tractor	1547	7623	1708
No tillage	722	3970	565
N means	911	5807	1168
Tillage means			
Hoe	266	4688	1102
Tractor	868	6339	1426
No tillage	490	3162	579
LSD (0.05) Tillage, T	NS	485	332
LSD (0.05) Nitrogen	442	363	NS
LSD (0.05) TxN*	NS	628	NS

* Used to test tillage means with N rates
\+ Maize variety 'Safita'
++ Maize variety 'Dobidi'

TABLE 2: EFFECT OF TILLAGE AND N ON MAIZE AND MILLET GRAIN YIELD AT NYANKPALA, DAMONGO AND MANGA, 1989

Tillage systems	Yield of Maize Nyankpala+	Damongo++	Yield of Millet Manga
	Kg/ha		
	0 kg N/ha		
Hoe	462	862	675
Bullock	420	2398	1623
Tractor	98	1715	1326
No tillage	587	673	953
N means	392	1412	1144
	60 kg N/ha		
Hoe	2006	2992	799
Bullock	1675	4290	1755
Tractor	791	4032	1415
No tillage	1672	3373	1253
N means	1536	3672	1306
	120 kg N/ha		
Hoe	2496	4817	719
Bullock	2102	5377	1774
Tractor	1434	5242	1307
No tillage	2457	3999	1184
N means	2122	4859	1246
Tillage Means			
Hoe	1655	2890	731
Bullock	1399	4021	1717
Tractor	774	3363	1349
No tillage	1572	2682	1130
LSD (0.05) Tillage, T	596	226	354
LSD (0.05) Nitrogen, N	462	281	NS
LSD (0.05) T x N*	NS	NS	NS

* Used to test tillage means with N rates
\+ Maize variety, 'Dorke'
++ Maize variety, 'Okomasa'

Summary

The response of crops to tillage differed from location to location. Maize and millet grain yields under bullock tillage were as high or higher than yields under tractor tilled plots. The preliminary results indicate the need to promote use of animal power in the Northern Region of Ghana for land preparation. Maize responded to N rates higher than 60 or 100 kg N/ha at Nyankpala and Damongo respectively. The late millet variety used at Manga for this study did not respond to N probably because of the low acidic soil conditions. The advantage of no tillage in moisture conservation is found in drier years. The years 1988 and 1989 were very wet years.

ɜrences

ɜrson R.L. 1990. No-till proso millet production Agron. J. 82: 577-580

/ins R.L. 1984. Soil adaptability for no-tillage. pp 42-65 In: R.E. Phillips and S.H. Phillips (ed) No-tillage agriculture. Principles and Practices Van Nostrand Reinhold Co. N. York

ɜ W.W. 1984. Energy requirement in no-tillage. pp 127-151 In: R.E. Phillips and S.H. Phillips (ed) No-tillage agriculture. Principles and Practices Van Nostrand Reinhold Co. N. York

‹son T.L., A.D Halvorson and B.B. Tucker. 1983. Soil fertility in dryland agriculture pp 297-332 In: H.E. Dregne and W.O. Willis (ed). Dryland Agriculture. Agronomy Series of Monographs, 23.

R. 1981. No tillage farming in the tropics. In. No Tillage Research: Research Reports and Reviews Editors: R.E. Phillips, G.W. Thomas and R.L. Blevins, Univ. of Kentucky, pp 103-151. Reports and Reviews, Univ. of Kentucky, pp 103-151.

‹e M.A. and F.M. Hons 1988. Tillage effect on seasonal accumulation of labelled fertilizer nitrogen in sorghum Crop Sci. 28: 694-700.

tin, J.H., W.H. Leonard, and D.L. Stamp. 1976. Tillage practices. pp 114-140. In. Principles of field Crop Production. 3rd ed. Mcmillan Publ. Co. Inc. N. York.

ɜinger, J.J., V.A. Bandel, G. Stanford, and J.O. Legg. 1985. Nitrogen utilization of corn under minimal tillage and moldboard plough tillage: I. Four-year results using labelled N fertilizer on an Atlantic Coastal Plain Soil. Agron. J. 77: 602-611.

llips R.E. 1984. Soil moisture. pp 66-88 In: R.E. Phillips and S.H. Phillips (ed). No-tillage agriculture. Principles and practices. Van Nostrand Reinhold Co. N. York.

llips S.H. 1984. Introduction pp 1-10. In: R.E. Phillips and S.H. Phillips (ed) No-tillage agriculture. Principles and practices. Van Nostrand Reinhold Co. N. York.

er O.W., and T.M. Mccalln 1980. Conservation tillage systems. Adv. Agron. 33: 1-58.

Wagger M.G. and H.P. Denton 1989. Tillage effects on grain yields in a wheat double-crop soybean, and corn rotation. Agron. J. 81: 493-498.

Discussion

M. BONSU

What was the texture of the soils used for the study? No tillage effect is due to the influence of organic matter. Usually it takes more than 2 years for no tillage to show beneficial effect. Do you draw your conclusion from the 2 year study?

J.J. AFUAKWA

Two sites were used in the two years. The soils belong to the Kumayili and Tingoli series (NAES, Annual Report 1987/88).

I agree the beneficial effects of no tillage are observed after many years. The site should not have been changed after the first year, but for the inclusion of the bullock tillage. The present site will be maintained for a long term study of the tillage systems.

P.K. KWAKYE

Comment: Results of N experiments conducted at Manga possibly on the same soil showed significant responses of late millet to N. There may be other factors responsible for low efficiency of the applied N. You may have a second look at the problem in the area.

J.J. AFUAKWA

Thank you very much for your suggestion.

T. DEL GIUDICE

In your summary we can see that late millet is not responding to an application of 60 and 120 kg N/ha. Could you give us the reasons for that non-response to N-fertilization?

J.J. AFUAKWA

The soils at the Manga station have been found to be acidic (at this workshop). At the level of acidity reported, in some cases with pH below 5.0, it is possible that we have nutrient inbalances.
Consequently, the N applied becomes unavailable to the crop, in this case, the late millet.

Other workers have found late millet to respond to N. The acidity problem at Manga therefore has to be corrected before any conclusion can be drawn.

R.H. GBENE

Mr. Chairman, I am at a lost why the speaker chose late millet since late millet does not respond to nitrogen. One would have felt that he chooses early millet which responds to nitrogen.

J.J. AFUAKWA

I disagree with the questioner that late millet does not respond to N. Other workers have reported that in their studies, late millet did respond to N.

H. BAUR

In your trials at Damongo, maize yields with zero application of nitrogen were up to 5 tons/ha. How would you explain these rather high yields?

J.J. AFUAKWA

The only possible explanations I can give are that
(1) Since the previous crop grown on the field was cowpea, it is possible the crop took advantage of the residual N; (2) The previous history of the field was not known; it is possible the field had been heavily fertilized before.
In any case it would have been good if soil analysis was done in order to know the nutrient status of the soil.

S. MENSAH

What is the reason why bullock tillage gave better results than tractor tillage?

J.J. AFUAKWA

I am sorry, I can give no possible explanation why yields under bullock tillage were higher than those under tractor tillage.

TOWARDS SUSTAINABLE RICE BASED FARMING SYSTEMS IN THE SAVANNA ZONE - THE ROLE OF GREEN MANURE CROPS.

W. Dogbe

Nyankpala Agricultural Experiment Station

Abstract

Rapid population growth in the northern savanna has brought about the need for increased food supply in the region. Despite government effort to increase rice production, the available supplies fall short of requirements, demanding renewed efforts. The role of fertilizers in increasing output is significant but their availability is limited by cost and uncertain supply due to importation problems. Reliance on the use of green manure crops which are abundant locally offers a possibility for supplementing nutrient requirements of crops. Green manuring opens up new opportunities for indigenous production and use at much lower cost. Research has clearly validated the manifold beneficial effects of green manure on soils, crops and the environment. In this paper the kind of green manure crops available for rice soils and their effect when incorporated into the soil are reviewed in relation to physical and chemical aspects. Certain known effects of green manure and also its integrated use with mineral fertilizers on the yield and growth of rice is also mentioned. Finally, the need for farm level green manure management practices is discussed and the conclusion is that, there is an urgent need to investigate farm level green manure management practices that will increase and sustain rice production in the savanna zone.

Introduction

Rice is one of the most important cash crops in the northern savanna where more than 60% of the nation's output is produced. The region has a potential paddy area of more than 500,000 ha. Out of the 80,000 ha which have been cleared, only between 20 - 45,000 hectares are cultivated annually (Asafo, 1985).

Over the past ten years, there has been a constant increase of about 6% every year in rice consumption, while production has been very unstable with fluctuations of more than 50% in some years (Table 1A, 1B). Rice production has rarely met 50% of the demand and yields have been unstable and low both in the savanna zone and at the national level. This means that existing policies and production systems have not met the rice requirements of the country. It would be desirable to increase rice production to match population growth by devising suitable production systems which will also ensure sustainability of the system.

TABLE 1A: PADDY PRODUCTION IN NORTHERN REGION AND IN GHANA AS A WHOLE

Year	Production (1000 tons)		Yield kg/ha	
	Ghana	N.R.	Ghana	N.R.
1980	78*	38.8	755*	1026
1981	97*	39.2	836*	1020
1982	36*	39.6	590*	800
1983	40*	11.7	1000*	300
1984	66*	28.3	1158*	1400
1985	--	--	--	--
1986	--	--	--	--
1987	62.5	38	880	950
1988	--	--	--	--
1989	--	--	--	--

Source: Ministry of Agriculture, Head Office Accra and Tamale Regional Office.
* Provisional estimates.

TABLE 1B: NATIONAL DEMAND, LOCAL AVAILABILITY, IMPORT AND DEFICIT OF RICE IN GHANA

Year	Total demand	Domestic* availability (1000 tons)	Import (1000 tons)	Deficit (1000 tons)
1980	107.1	53.8	43	10.3
1981	115,5	67.3	40	8.2
1982	121.2	24.0	29.5	67.7
1983	127.0	28.2	50	48.8
1984	124.2	47.0	30	47.2
1985	--	--		
1986	--	--		
1987		50		
1988	--			
1989				

Rice farmers in the northern savanna are aware of the usefulness of inorganic fertilizers in increasing rice yields. However, financial constraints have prevented the use of fertilizers on a wider scale. The situation has been further aggravated by prohibitive prices of chemical fertilizers and other agrochemicals. Real rice prices are falling whilst the cost of inorganic fertilizers is on the increase as a result of energy crisis and policy decisions which have removed subsidies on agricultural inputs. The resource-poor farmer is not able to adopt and reap the full benefits of modern technology under the savanna conditions where fertilizer is a must for good yields.

A pertinent question is whether there is any alternative to complete reliance on inorganic fertilizers to increase rice

production. Can a cheaper, reliable locally available, soil fertility improvement technology be recommended to small scale rice farmers of the savanna zone who produce the bulk of the nation's rice? Research evidence and past experience show beyond doubt that organic matter based farming systems, if judiciously used, in combination with inorganic fertilizers can help to increase and sustain rice production. Three promising alternatives to chemical nitrogen fertilizer are green manure, farm yard manure and crop residues. This paper addresses the role that green manure crops could play in rice production in the savanna zone of Ghana.

Green manuring

Green manuring is a process whereby fresh plant materials containing high amounts of nitrogen are incorporated into the soil and then allowed to decompose so that they can serve as a source of nitrogen for subsequent crops.

The practice of green manuring has been traced to China as early as 1134 B.C. (Joffee, 1955). Green manures were recognized as important sources of nitrogen for rice-based cropping systems before the advent of modern agriculture in countries such as India, Japan and China. However, during the last several years, green manuring has declined in popularity except in China. The practice has not been favoured by farmers for purely economic reasons. The cost of a green manure crop in terms of labour, land and water utilization often outweigh the return; often it is less than the gain from an alternative cash crop (Domenergues, 1982). It is also possible that no green manuring strategy has been found suitable to the peasant farmer and that in previous years he could still afford to buy chemical nitrogen fertilizers. However, present economic realities dictate that we take a second look at green manuring as a mechanism of providing nitrogen to non- leguminous crops especially in a rice based cropping system.

Green manures and their nutrient content

Green manures are comparatively high in nitrogen, low in C:N ratio and contain considerable amounts of plant nutrients such as potassium, calcium and minor elements (Tanaka, 1978). According to Hesse (1984), Azolla can provide 1.5 kg N/ha per day which is about 500 kg N/ha per year. A 50 to 60 days old Sesbania acuelata adds between 45-150 kg N/ha (Singh et al., 1990). The authors found that green manure N was equal to or better than urea N in increasing grain yield of rice.

Yoshida and Sato (1934) reported that the decomposability of green manure is governed by the N content or C:N ratio and lignin content. As the N content decreases or the C:N ratio increases, the decomposability of green manure decreases. They concluded that generally a C:N ratio of about 10 is preferable

for a green manure. The effectiveness of green manures depend on several other factors including the time of application, soil characteristics and soil moisture regimes during crop growth (Venkataraman, 1984).

Effect of green manure on the physical and chemical properties of the soil.

Accumulated organic matter in the soil originating from long-term application of organic materials improved the physical properties of paddy soils. Through a decrease in solid ratio, bulk density, specific gravity and crushing strength (Norio et al., 1984; Gu and Wen, 1981). Biswas et al. (1970) reported that in a rice fallow rotation for 10 years in an alluvial sandy loam, organic manures improved water stable aggregation, hydraulic conductivity and water retention.

In most soils the continued use of mineral N fertilizers tend to lower pH values and organic manures have a buffering effect (Hesse, 1984). Hesse further observed that aluminium induced acidity, if present, can be partially remedied by organic matter complexing with Al. According to him one positive effect of organic materials added to soils is an increase in cation exchange capacity. There is also an increase in total C which is likely to be more noticeable in flooded soils than in dryland soils where, usually, no spectacular build up of C occurs. Immediate changes in total N and especially available N will depend largely upon microbial activity but an increase in potentially available N could be expected. In an experiment to study the relative merits of Sesbania acuelata, Crotolaria juncea, Phaseolus trilobus and Vigna unguiculata, Sanyasiraju (1952) observed that all the green manure crops contributed positively to soil organic matter and N.

Green manures and their effect on growth and yield of rice.

The effects of incorporating a legume green manure on rice yield and soil properties have been thoroughly documented in many countries (Pandey et al., 1983). In China, which has a long history of green manuring, Qi-Xiao Wen (1984) reported that on the average, applying 1 ton (fresh weight) of winter green manure to rice will increase yield by 30-80 kg/ha, depending on soil fertility, rate of application and rice cultivar. Pandey and Moris (1983) estimated a 100 kg grain yield increase per ton of green manure incorporated.

Dogbe et al. (1990) reported that incorporating the remains after first priming of a 60 day cowpea or mungbean planted before rice, contributed N that supported rice yield which was not significantly different from the crop that received 60 kg N/ha as inorganic N. Ploughing in 4.7 tons green gram haulms per hectare along with the application of 60 kg/ha inorganic N gave

a rice yield of 6.9 t/ha which was equivalent to the yield when 120 kg N/ha of inorganic fertilizer was applied (Meelu and Rekhi, 1981). Tiwari et al. (1980) reported that green manure plus 40 kg N/ha compared favourably with 120 kg N/ha alone in increasing rice yield. A wheat crop following the rice crop preceded by green manure registered a 54% increase in yield compared with the wheat crop that followed rice without green manuring.

While studying the effect of Sesbania green manuring on ammonia volatilization loss in wetland soils, Khind et al. (1989) observed that no ammonia volatilization occurred in soils amended with green manure. Remasamy et al. (1988) reported 4.0 t/ha grain yield when 12.5 t/ha of Sesbania acuelata was applied compared to 3.2 t/ha when 40 kg N/ha was applied as inorganic N. When 40 kg N/ha was applied with 12.5 t/ha Sesbania, 4.6 t/ha yield was obtained which was superior to application of 80 kg N/ha as inorganic N.

Bhadwaj et al. (1981) found that manuring with Crotalaria juncea saved about 75 kg N/ha; Sesbania acuclata, 50 kg N/ha and Ipomea carnea, 25 kg N/ha in ricefields. The additional rice yield over conditions with no green manuring ranged from 225 kg/ha in the case of Ipomea to 1966 kg/ha for Crotolaria juncea.

Diara et al. (1987) working on Azolla in West Africa recorded that in northern Senegal where farmers apply nitrogen at high rates (120 kg N/ha) up to 50% of the mineral N can be supplied by Azolla. In the mangrove swamps of Sierra Leone, Azolla N can completely replace mineral Nitrogen at the recommended rate of 40 kg N/ha. Azolla incorporation in rice field increased grain yield from 13 to 54% (Singh, 1979; Kannaiyan et al., 1982).

Evaluating the importance of Luceana as green manure for lowland rice, Jeyaranman et al. (1987) reported that application of Luceana as leaf manure with 75 kg N/ha gave a grain yield of 4.8 t/ha compared to 4.3 t/ha yield obtained from application of 100 kg inorganic N/ha. Applying 50 kg N/ha in the form of Luceana gave 4.3 t/ha paddy.

In an experiment to study the integrated effect of organic and inorganic N on rice yield, Shukla et al. (1989) reported that yield with Sesbania alone equaled the yield of 90 kg N/ha applied as urea. Sesbania with inorganic fertilizer at 30 kg N/ha urea increased grain yield by 9% over urea alone applied at 90 kg N/ha but was equal to the yield of 120 kg N/ha applied as prilled urea or urea super granules. The highest N use efficiency was recorded when green manure (Sesbania) was applied.

The northern ricelands and possible green manure crops available to the farmer

In the northern savanna, irrigated, rainfed upland and lowland rice cultures are practiced. However, the rainfed lowland rice is the predominant practice. A look at the rainfed ricelands reveal that more than 50% of the lowlands (valley bottoms) are waterlogged for at least two months of the cropping season. At the Nyankpala Agricultural Experiment Station (NAES), work on the evaluation of various green manure crops for the upland and lowland farming systems has identified some promising green manure crops.

Estimates of nitrogen fixation by some grain legumes under upland conditions at Nyankpala showed that a 60-65 day cowpea (CV IT82-18) fixed 201 kg N/ha with a net nitrogen of 125 kg/ha in the residue (Dakora, 1985). Such grain legumes can be grown, primed once and ploughed in as a green manure.

A national survey carried out by NAES under the auspices of the WARDA Azolla Project has indicated the presence of Azolla strains in waters around Navrongo, Accra and Kpong (Dakora, 1985). The station has started Azolla germplasm evaluation to identify those with the greatest potential as green manure crop for this area. Some of the ricelands in the savanna region of Ghana support a dense population of active nitrogen fixing fallow legumes but their nitrogen contribution has not been assessed. Upland rice soils at Nyankpala, Bontanga and Tono are often colonised by local species of Crotolaria, Centrosema and Tephrosia which fix nitrogen (Bennet and Schork, 1979). Lowland rice soils (hydromorphic) around Nyankpala, Tolon, Golinga and Fumbisi valley have also been observed to support dense population of Sesbania species which showed profuse and effective nodulation around the stem. A nursery of all these fallow legumes has been established at Nyankpala for evaluation and selection as green manure crops for the region.

Conclusions

1. Evidence from the literature suggests that green manures have tremendous agronomic potentials which need to be explored.

2. There is need for research to identify effective green manure technology for the region. Such a research programme has to address the following:

   i. Development of cost effective methods of producing and incorporating green manure crops into the soil at the farm level.

ii. Identification of management practices which will increase the gain in rice yield from green manuring, over and above that realized by inorganic N substitution alone.

iii. Within a farming systems framework:

a. identify environmental niches where green manure offers greatest potential.

b. quantify the opportunity cost of land and other inputs to green manure production.

c. examine existing systems of green manuring practiced by farmers, if any, and identify ways of improving such systems.

References

Amerasiri, S.L. 1978. Organic recycling in Asia - Sri Lanka. F.A.O. Soil Bull. 36:119-133.

Asafo, C.K. 1985. The rice industry in Northern Ghana present status and future. Paper presented at National Rice Workshop, Tamale. 26-28 March 1985.

Bennett, A. and W. Schork. 1979. Studies towards a sustainable agriculture in northern Ghana. An internal working paper on agro-ecosystems. Research Centre for International Agrarion Development. D - 6 900 Heidelberg 1, Germany.

Bhardwaj, S.P., S.N. Prasaad and G. Singh. 1981. Economising N by green manure rice - wheat rotation. Indian J. Agric Sci. 51:86-90.

Biswas, T.D., M.R. Roy and B.N. Sahu. 1970. Effect of different sources of organic manures on the physical properties of the soil for growing rice. Indian Soc. Soil Sci. 18:233-242.

Dakora, F.D. 1985. Microbiological approach to rice soil fertility. Paper presented at the National Rice Workshop in Tamale. 26-28 March 1985. Nyankpala Agricultural Experiment Station, Tamale.

Dogbe, W., Y. Guirand, R. Kahane and O. Kuperminc. 1990. Sequential cropping of legume and rice on the rainfed lowlands of Northern Ghana. Abstract. Tenth Annual maize and cowpea workshop, Kumasi. March 20-23 1990. Ghana Grains Development Project.

Diara, H.F., H. von Brandt., A.M. Diop and C. Van Hove. 1987. Azolla and its use in rice culture in West Africa. In: Azolla utilization. p 147-154 IRRI.

Dommergues, Y.R. 1982. Scarcely explored means of increasing the soil N pool through biological N_2 fixation. In: Whither soil research. Panel discussion papers. 12th International Congress of Soil Science. New Delhi. p 138-149.

Gu Rong-shen and Qi-xiao Wen. 1981. Cultivation and application of green manure in paddy fields of China. In: Proceedings of symposium on paddy soils. 19-24 Oct. 1980. China.

Hesse, P.R. 1984. Potential of organic materials for soil improvement. In: Organic matter and rice. IRRI. p. 35-43.

Jeyaraman, S. and S. Punshothamas. 1987. Luceana as green leaf manure for lowland rice. Int. Rice News. 13: No 5:27.

Joffee, J.S. 1955. Green manuring viewed by a Pedologist. Adv. Agron. 3.142-146.

Kannaiyan, S., M. Thangaraju and G. Oblisani. 1982. Studies on multiplication and utilization of Azolla biofertilizer for rice crop. Abstract. National symposium on biological nitrogen fixation. New Delhi. 50 p.

Khind, C.S., A. Garg and M.S. Bajwa. 1989. Effect of Sesbania green manure on ammonia volatilization loss in wetland soils. Int. Rice News. 14: 31.

Meelu, O.P and R.S. Rekhi. 1981. Mung straw management and nitrogen economy in rice culture. Int. Rice Res. Newl. 6.

Meelu, O.P. and R.A. Morris. 1987. Critical factors for green manure management in rice - based cropping systems. Paper presented at the symposium on sustainable Agriculture. May, 25-29 1987. Los Banos, Philippines.

Norio Nakaya and S. Motomura. 1984. Effect of organic and mineral fertilization on soil physical properties and hydrophobicity of soil organic matter. In: Organic matter and rice. p 387-398. IRRI.

Pandy, R.K. and R.A. Morris. 1983. Effect of leguminous green manuring on crop yields in rice based cropping systems. Paper presented at the international rice research conference. April 23 - 28 1983. IRRI. Los Banos, Philippines.

Qi-xiao Wen. 1984. Utilization of O.M in rice Production. In: Organic matter and rice. 45 - 56. IRRI

Ramasamy, S., A.S. Dawood and K.N Chinaaswami. 1988. Organic and inorganic N effect on rice. Int. Rice News. 13: 5-29.

Sanyasiraju, M. 1952. Role of organic manures and inorganic fertilizers in soil fertility. Madras Agric J. 39: 132-139.

Shukla, G., P.C. Pandey, P.S. Birht and P. Lal. 1989. Integrated effect of organic and inorganic N on rice yield. Int. Rice Res. News. 14: 4-31.

Singh, P.K. 1979. Use of Azolla in rice production in India. In: Nitrogen and rice. p 407 -417. IRRI.

Singh, Y., B. Singh, O.P. Meelu and M.S. Maslina. 1990. Nitrogen equivalence of green manure for wetland rice on coarse-textured soils. IRRN. 15 (1) 23.

Tanaka, A. 1978. Role of organic matter in soils and rice. IRRI.

Tiwari, K.N., A.N. Pathak and S.P. Tiwari. 1980. Fertilizer management in cropping systems for increased efficiency. Fert. News. 25:3-20.

Venkataraman, A. 1984. Development of organic matter based agricultural systems in Southern Asia. In: Organic matter and rice. p. 57 - 70. IRRI.

Yoshida R. and M. Sato. 1934. Effect of nitrogen fertilizer on the decomposition of green manure. Soil. Agric. Hort. 9: 1927-1941.

Discussion

F.N.A. ODOI

I wish to draw attention of researchers towards green manuring of rice fields. Work on Azolla was carried out for several years at ARS, Kpong. In this respect livestock seems very much to be the "step child" of research focus in this area despite the prominent place it occupies in the farming system of these regions.

W. DOGBE

Thank you for your suggestion. We have already started some collaboration with ARS Kpong in that direction. Your suggestion on the integration of livestock in the farming system is well taken but I think this can be better organised through collaboration with the Animal Research Institute which is just close to us.

A. B. SALIFU

Could you elaborate more on the significance of the C:N ratio?

W. DOGBE

The C:N ratio is important because the decomposability of green manure is governed by its C:N ratio and lignin content. Incorporation of O.M with high C:N ratio like rice straw means tying up of the soil N and temporally inducing N hunger because the N in the O.M is not readily available to the soil microbes which will mineralize the O.M. The reverse holds for O.M with low C:N ratio like Sesbania. O.M with high C:N ratio should be applied with inorganic N. Generally a C:N of about 10 is preferable for green manure crops.

H. RUDAT

Why legumes (Sesbania, Cowpea etc) in rice production? Where do you place legumes in the cropping system?

W. DOGBE

Sesbania and the other legumes have been chosen because they are fast growing, have a high nitrogen fixing potential and are able to grow on ricelands. In the cropping system, they may be used as preceding crops or intercrop, with rice where applicable.

T. DEL GUIDICE

Wouldn't you face a mineralisation problem in incorporating farm manure on a water-logged low-land rice field (lack of O_2)?

W. DOGBE

Generally mineralisation is lower in flooded soils than upland soils but when green manure crops with low C:N are incorporated, it is said that the N is readily available to the rice plant. I therefore don't see the problem of mineralisation arising with the crops I intend using.

T. DEL GUIDICE

Could the incorporation of rice straw not contribute to improve the organic matter content in the soil? In addition to the incorporation of O.M, N application could bring the C:N ratio to a reasonable level.

W. DOGBE

Yes, straw application contributes to the organic matter content of the soil, but there is a problem. Nitrogen content as we saw from the table is very low therefore to get a reasonable amount of nitrogen from the straw you need to incorporate a large amount of straw which the farmer may not be able to do under his present cultivation method.

The addition of inorganic N will lower the C:N of the straw but the question is whether under the very low N levels in the savanna it will be economical for the farmer in the short run. Research has to look into that.

J.A. KWARTENG

You indicated that you were limiting the discussion to Research and Extension but I don't remember you making mention of Extension.

W. DOGBE

I did not make mention of extension simply because time could not allow me. I must say that right from the problem identification up to recommendation of proven technologies, extension will be actively involved.

E.A. ADDISON

The title of the paper was Towards sustainable rice-based farming systems but all the proposals dealt with green manure? What should be the contributions of livestock and how can they be integrated into the proposals?

W. DOGBE

I must agree that "Towards sustainable rice-based cropping systems" better suits the title of the paper. However I chose farming systems because the workshop was on improving farming systems. A terminology that I personally has my reservations about. I say this because farming systems research all over even in international institutes has been almost synonymous to cropping systems research.

Integration of livestock can contribute farmyard manure for the rice farm while the crop residues serve as food for the livestock. Livestock would increase farmer's income and protein supply, but as I have already mentioned such an integration is practically feasible through cooperation with the Animal Research Institute.

J.A. ADOGOBA

Why has the speaker failed to mention something about the atmospheric N fixation of the plants he mentioned?

W. DOGBE

All plants mentioned have the ability to fix atmospheric nitrogen and this was even shown in Table 2 where N content in legumes ranged from 3-5% per kilogram dry matter.

SESSION 3

CHAIRMAN: PROF. D.M. OSAFO, UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI.

THE YIELD OF SEED YAMS GROWN FROM MINISETTS AS INFLUENCED BY MULCH

Cecil Osei

Nyankpala Agricultural Experiment Station

White yam (Dioscorea rotundata Poir.), is an important carbohydrate staple in West Africa, the Carribean and some Pacific islands (Coursey, 1967). Current production levels in West Africa are stagnant (Ngambeki, 1981), partly because of planting material which is also the source of food (Alvarez and Hahn, 1984).

The weight of seed yams planted vary with the agro-ecological zone but the average in the sub-region is between 150-1000 g. Traditionally, ware yam producers obtain their planting material or seed yams by "milking" or cutting ware yam into setts or by "junking"(cutting of heads) (Okigbo and Ibe, 1973). In all these methods, the proportion of tuber yield used for planting are substantial and account for about 35-54% of the total yam production costs (Lyonga, 1981).

In the search for a cheaper method of rapidly multiplying improved cultivars of Dioscorea spp. for evaluation and distribution to farmers, studies at the National Root Crops Research Institute at Umudike Nigeria, revealed that the smaller the yam piece planted, the higher the multiplication ratio (Okoli et al,1982). This led to the development of the minisett technique, in which 25 g cut setts of yam are planted for the production of seed yams. This method was further improved at the International Institute of Tropical Agriculture with a recommendation of mulching with plastic sheets. The efficient performance of plastic sheets is attributed to the improvement of soil moisture regime, reduction in soil temperature fluctuation and decreased weed infestation. Yields of 6.0 - 14.5 t/ha (12,000 - 29,000 seed yams/ha) of improved variety of D. rotundata have been obtained on farmers fields (IITA, 1984).

In spite of the obvious advantage of using plastic mulch, its large-scale use may increase pollution of the fields. A biodegradable mulch is needed. Also imported plastic mulch may be unavailable and too expensive for farmers to use. The purpose of this study therefore was to find cheap, degradable and easily available mulch substitute for plastic sheets in seed yam production.

Materials and methods

Site and soil

The study was carried out in 1989 at the Nyankpala Agricultural Experiment Station. The site had been lying fallow for three years. The soil is a "Savanna Ochrosol of the Tolon series" (FAO classification) with a pH of about 6 in water (1:2) and 0.04% total Nitrogen. The top soil is a coarse loam structure.

Treatments and experimental design

A randomised complete block design with four replicates was used. The treatments were

1. Lightweight black plastic sheets
2. Andropogon spp. grass at 5 t/ha
3. Rice husk at 5 t/ha
4. No mulch (bare ridges)

Presprouting of minisetts

Where yams of the local cultivar "kpuna" were cut into 25g pieces and treated in a fungicide/bacteriacide suspension of 24 g of "Kocide 101" and four handfuls of wood ash in 4 litres of water. The setts were air dried under shade for 2 hours and presprouted by nursing in baskets containing loamy soil. Each basket contained a hundred setts in two layers. Water was applied when necessary.

Field planting

The field was chisel ploughed and harrowed. Ridges 1 m apart and 10 m long were made with hoes. The grass mulch was applied on the day before planting whilst the plastic and rice husk were applied at planting. Sprouted minisetts were planted on 14th June, seven weeks after nursing, with a spacing of 25 cm intra-row in plots measuring 10 m x 3 m which gives a plant population of 40,000 per hectare.

Weeding was done by hand-pulling on treatments 1 and 3 and by hoe on the "no mulch" plots.
Plants were harvested six months after planting.

Results and discussion

Field plant growth

Plants on plots mulched with lightweight black polythene grew faster and appeared greener during the growth period than all the other treatments.

Weed infestation was minimal on plastic mulch plots. The Andropogon grass mulch, in view of its stiff nature was often seen to have rolled into the furrows thus exposing the ridges. There was a faster weed regrowth on these plots than the rice husk or bare ridges.
"Bare ridge" plots suffered severe erosion similar to that on Andropogon grass plots. In the case of rice husk plots, there was very little erosion probably due to the soil binding nature of the material.

Tuber yield

The total tuber yield obtained under plastic mulch was significantly higher than that from the other treatments. Table 1A shows the total yield, total number of tubers, and "seed yield" of tubers weighing between 0.1 and 1 kg, which is used by most farmers in the northern savanna zone of Ghana. Table 1B indicates the same parameters in a weight category of between 0.2 and 1 kg, which is considered as the "economic weight" of seed yams (Diehl, 1982) or "saleable seed yams" (Egwilo and Okoli, 1988). Similar results were obtained in a mulch experiment on the fresh root yield of cassava at IITA (1976) involving 22 mulch treatments (including those used in this study), in which black polythene and rice husk produced the highest yield whilst Andropogon spp grass and bare ridges had the lowest yields among these four treatments.

TABLE 1A: TUBER YIELD AND AVERAGE TUBER WEIGHTS OF SEED YAMS GROWN FROM MINISETTS AS INFLUENCED BY MULCH, NYANKPALA, 1989

	TOTAL YIELD		SEED YIELD (0.1 - 1 kg)				
Mulch Treatment	kg/ha	#/ha	kg/ha	% of total	#/ha	% of total	Average weight (kg)
PLASTIC	9753a	41,667	8413a	86.3	26,333	63.2	0.32
RICE HUSK	5654b	42,250	4663b	82.5	22,833	54.0	0.20
NO MULCH	4096b	41,083	2801b	68.4	15,000	36.5	0.19
ANDROPOGON GRASS	3675b	39,500	2444b	66.5	14,416	36.5	0.17

In the first weight category (0.1- 1 kg), the percentage of seed harvested under all the treatments can be used to plant more than 1 hectare of crop which makes it superior to the traditional system where seed from one hectare is needed to plant a hectare of crop. However, in the second weight category, only the yield from the plastic mulch could be used to plant a hectare or more (planting at 10,000/ha).

TABLE 1B: TUBER YIELD AND AVERAGE TUBER WEIGHTS OF SEED YAMS GROWN FROM MINISETTS AS INFLUENCED BY MULCH NYANKPALA, 1989.

	TOTAL YIELD		SEED YIELD (0.2-1 kg)				
Mulch Treatment	kg/ha	#/ha	kg/ha	% of total	#/ha	% of total	seed weight (kg)
PLASTIC	9753a	41,667	7221a	74.0	18,701	44.0	0.39
RICE HUSK	5654b	42,250	2637b	46.6	8,950	21.2	0.29
NO MULCH	4096b	41,083	1414b	34.5	4,761	11.6	0.30
ANDROPOGON GRASS	3675b	39,500	744c	21.1	2,930	7.4	0.26

The total number of tubers harvested indicated an average of 1 tuber per stand in all the treatments and therefore a multiplication ratio of one in terms of numbers.

The percentage weight distribution of tubers under the various mulch treatments are shown in Table 2. Tubers greater than 1 kg were produced only under plastic mulch. A substantial percentage of tubers produced under all treatments were less than 0.1 kg, which are not considered as seed yams by many authors (Okoli, 1978; Okigbo and Ibe, 1973 and Sadik and Okereke, 1975). The percentage falling into the category of saleable seed yams in all the treatments were low. However, considering a weight category of 100 - 500 g, the percentage of yield obtained under rice husk (53%), is comparable to that of plastic mulch (52%). This weight category can be conveniently used by farmers for planting in view of their high "sett multiplication ratios" (SMR), which is the ratio of the fresh weight harvested to the planting rate (1.0 t/ha) (see appendix A).

Onwueme (1978) suggested 150 - 300 g setts for commercial ware yam production, which will optimise sett size and SMR's (Akorada, 1985). This suggests that regardless of the superior yield of the plastic mulch, at least 12% of the tubers produced are far above this optimum (Table 2). In this instance the rice husk mulch appears better despite its lower yields. The SMR also gives an indication of the efficiency of the various mulch treatments. The SMR's of the total yield and both categories of seed yield (0.1 - 1 kg and 0.2 - 1 kg) are shown in Table 3. The values fit into the range of 1.8 - 18.4 reported by Egwilo and Okoli (1988) for five varieties of D. rotundata over 3 seasons.

TABLE 2: PERCENTAGE DISTRIBUTION OF TUBER SIZES OF SEED YAMS GROWN FROM MINISETTS AS INFLUENCED BY MULCH, NYANKPALA, 1989

MULCH TREATMENT	WEIGHT DISTRIBUTION (%)				
	<100 g	100-200 g	201-500 g	501-1000 g	>1000 g
PLASTIC	35.8	18.8	33.4	11.2	0.8
RICE HUSK	46.0	32.9	21.1	--	--
NO MULCH	64.3	24.1	11.6	--	--
ANDROPOGON GRASS	63.3	29.3	7.2	0.2	--

TABLE 3: SETT MULTIPLICATION RATIO [SMR] OF TOTAL YIELD AND SEED YIELD AS INFLUENCED BY MULCH, NYANKPALA, 1989.

Treatment	Total yield	(SMR)	Seed yield[1]	(SMR^1)	Seed yield[2]	(SMR^2)
Plastic	9753	(9.7)	8413	(8.4)	7221	(7.2)
Rice husk	5654	(5.6)	4663	(4.7)	2637	(2.6)
No mulch	4096	(4.1)	2801	(2.8)	1414	(1.4)
Andropogon grass	3675	(3.7)	2444	(2.4)	744	(0.7)

Planting rate = 1.0 t/ha.
1 - Based on the weight category of 0.1 - 1kg
2 - Based on the weight category of 0.2 - 1kg

The number and total weight of tubers less than 0.1 kg and their average weights under the various treatments are shown in Table 4. The average weight of these tubers was highest for the plastic mulch and differed from the other mulches by 37 g.

A preliminary gross margin analysis of the treatments showed that despite its high initial cost outlay, plastic mulch gives the highest profit margin, followed by rice husk, bare ridges and grass mulch in that order. All the treatments except Andropogon grass were profitable.

This study confirms the superiority of plastic mulch. Considering the percentage of tubers that could be used as seed in the northern savanna zone (150 - 500g), rice husk as mulch has a good potential. These results need to be verified by more detailed experiments.

TABLE 4: TUBERS LESS THAN 100 G FROM YAM MINISETTS AS INFLUENCED BY MULCH, NYANKPALA, 1989.

Treatment	#/ha	Average weight (g)
PLASTIC	15,334	87
RICE HUSK	19,417	50
NO MULCH	26,083	50
GRASS	25,084	50

APPENDIX A: REPORTED TUBER YIELDS AND THEIR ASSOCIATED SETT WEIGHTS AND SMR

SETT WEIGHT (g/stand)	FRESH TUBER YIELD (g/stand)	SMR	REFERENCE
75	3100	44.3	Kang & Wilson (1981)
1002 (50)[a]	3520	35.2	Lal & Hahn (1973)
203	2460	12.1	Gurnah (1974)
300	4295	14.3	Kpeglo et al (1981)
405	2112	5.2	Gurnah (1974)
500	2000	4.0	Wilson (1982)

References

Akoroda, M. O. 1985. Optimizing sett size and sett multiplication ratio for ware yam production in Guinea yams. Field Crops Res. 12(4): 377 - 385.

Alvarez, M. N. and Hahn, S. K. 1984. Seed Yam Production. In: E. R. Terry, E. V. Doku, Arene O. B. and N. M. Muhungu (Editors), Tropical Root Crops: Production and its Uses. International Research Development Centre, Ottawa, Ont. IDRC 221e. pp 129-132.

Coursey, D. G. 1967. Yams. An account of the native origins, cultivation and ultilization of the useful members of Dioscoreacea. London, England. Longmans. 230 pp.

Diehl, L. 1982. Smallholder Farming Systems with Yam in the Southern Guinea Savanna of Nigeria. GTZ. 356 pp.

Egwilo, N. and Okoli, O. O. 1988. Evaluation of Yam Cultivars for Seed Yam Production using the Minisett Technique. Field Crops Res. 19(2): 81 - 90.

IITA, 1976. International Institute of Tropical Agriculture. Annual report for 1975. IITA, Ibadan, Nigeria.

IITA, 1984. International Institute for Tropical Agriculture. Annual Report for 1983. IITA, Ibadan, Nigeria.

Lyonga, S. N. 1981. The Economics of Yam Cultivation in Cameroon. In: E. R. Terry, K. A. Oduro and F. Caveness (Editors). Tropical Root Crops; Research Strategies for the 1980's. International Research Development Centre, Ottawa, Ont. IDRC - 163e. pp 208 -213.

Ngambeki, D.S. 1981. Trends in production of Root Crops in Africa. In: Agricultural Economics Information Bulletin No. 3. IITA, Ibadan, June 1981 pp 1-5.

Okigbo, B. N. and Ibe, D. G. 1973. A new method of yam propagation. Paper presented at the 3rd Symposium of the International Society of Tropical Root Crops, IITA, Ibadan, Nigeria, 2 - 9 December 1973.

Okoli, O. O. 1978. Stimulating Axillary Buds in Yams (Dioscorea spp.). Expl. Agric. 14: 89 - 90.

Okoli, O. O., Igbokwe, M. C., Ene, L. S.O. and Nwokoye. 1982. Rapid Multiplication of Yam by the Minisett Technique. Research Bulletin No. 2 of N.R.C.R.I.

Onwieme, I. C. 1978. Tropical Root and Tuber Crops. New York, U.S.A. John Wiley and Sons. 234 p.

Sadik, S. and Okereke, O. U. 1975. A New Approach to the Improvement of Yam (Dioscorea rotundata). Nature 254 (5496): 134 - 135.

Discussion

T. DEL GUIDICE

Even though the rice husk is likely to be blown or washed away from the ridges your results showed yield advantages due to this particular mulch. Do you think that the rice husk had a positive effect on the soil fertility?

C. OSEI

Your observation is quite correct. Though some of the rice husk was washed off initially, the rest were crusted and remained on top of the ridges. Weed infestation was low afterwards. Since no signs of nitrogen immobilization was observed and it seems too short for mineralisation of the husks, the yield advantage needs to be investigated further with regard to the C:N ratio, and nutrient availability before and after the season.

J.A. ADOGOBA

How many yam minisetts can one get from a "normal" tuber of yam?

C. OSEI

A "normal" tuber of yam weighing about 2 kg can give 30-40 setts. However, the normal tuber size used in this technique is about 1 kg which will give you 25-30 setts.

B. BANFUL

How many replications did you use?

C. OSEI

Four replications.

P. K. DROBOH-AMEYAW

Has staking any effect on seed yam multiplication?

C. OSEI

Experiments by Okoli et al. (unpublished) have shown that staking has no effect on yield when plots are mulched. Staking gives large tubers that may not be suitable for planting.

S. ABDEL-RAZAQUE

How practical will your recommendation be on the results of plastic mulch to the farmer?

C. OSEI

Since plastic mulch is expensive, about ¢100,000 per ha according to our estimates, this type of mulch is definitely not likely to be recommended to our farmers.

J.C. TIA

The traditional method of yam mulching is the use of leaves but in your experiment no leaves have been tried. Is it an oversight or intentional and why?

C. OSEI

Leaves are mostly used in ware yam production. It's gathering and transportation makes it relatively unavailable to the farmer compared to the two organic materials used in this experiment.

O. ABDEL-RAHMAN

Is it not possible to modify the ridges on which to plant the yam setts since our farmers are used to planting yam in mounds?

C. OSEI

This method of seed yam production, with a plant population density of 40,000 plants/ha makes the use of ridges less laborious and more economical than mounds which is suitable for the production of ware yams. Considering the range of the sizes of tuber expected (between 0.1 and 1 kg), ridges are the most appropriate.

D.M. OSAFO

Are you going to take into consideration the cost of weed control in making your recommendations?

C. OSEI

Yes. Initially, the working topic of this experiment was the economies of the use of the various mulch, so the preliminary gross margin compilation has been made which included weed control costs.

YIELD AND NUTRIENT UPTAKE OF MAIZE GROWN ON SOME TYPICAL UPLAND SITES OF THE NORTHERN VOLTA BASIN

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1. Introduction

It is widely accepted that soils react - according to their varying physical and chemical properties - differently to the same set of cultural practices. Usually, yield and yield stability are used to measure how good soil and cultural practices fit together. However, this means that a certain cropping system, which has proved to give good and stable yields on one site, has to be tested on a variety of sites in order to find out whether a general recommendation can be given or differentiations have to be made. The selected experimental sites have to be representative for the relevant area. The expression "site" is here being understood as location with specific growing conditions for plants resulting from soil properties and micro-/ macro-climatic conditions.

Schmidt and Frey (1988) have proved on a typical upland site in the northern Volta Basin and within the area of the Basement Complex that under permanent cropping the rotation of various crops was mostly superior to the mixing of the same crops with regards to absolute yield level and yield stability. On a site adjacent to this plot Haerdter (1989) found corresponding results for the cultivation of maize and cowpea. On farmers fields Sipkens (1990) conducted similar trials but unfortunately without characterizing the sites sufficiently. However, his results showed similar trends. Based on these results and the work of Adu (1957) as well as our own investigations with regard to the prevailing soil pattern, six sites on five different soil series within the experimental area of NAES were selected and an identical maize/groundnut trial (as a typical example for a cereal/legume succession) was conducted on each of them. This paper reports the 1988 results when maize (Zea mays, L.) was cultivated as first crop.

2. Materials and methods

2.1. Selection of sites

The following soil series along a catena were selected:

Tingoli, Tolon and Nyankpala Series (representing plateau and upper slope positions; criterion for differentiation was mainly soil colour; see Adu, 1957), Kumayili Series (representing middle slope) and Kpalsawgu Series (representing lower slope). The first three series are derived from sandstone or sandy shales and fall into the Luvisol or Lixisol group (according to the FAO-classification). The middle slope soil is derived from colluvium and can be grouped as Haplic Lixisol

(petroferric phase). The two lower slope profiles are derived from colluvial material (topsoil) and mudstone or clay-shales (subsoil) and can be classified as Gleyic Acrisols. The two lowest catena sites, Changnayili and Volta Series, as located in the valley bottoms (Adu, 1957) were left out in this investigation, since the periodically high groundwater table only allows rice monoculture.

The upper catena soils are mostly sandy. The two lower slope profiles have sandy to silty topsoil. The gravel content increases with soil depth in all soils (from 10-30 to 50-80%). The organic matter content of the upper catena soils is generally low (<1%), while that of the lower slope soils is slightly higher. Few aggregates exist in the topsoils. Therefore, storage of plant available water in the upper catena soils is not only limited by an unfavourable pore size distribution (sufficient for about 15 days under maize; Hauffe, 1989), but also by low infiltration. However, during wet periods these soils have the advantage of a good internal drainage. For the lower slope sites, even in years with normal rainfall distribution, periodic water logging (actual Air Volume < Air Capacity) is possible because of very low hydraulic conductivity in the subsoils and additional interflow from the upper slope .

Generally, the Cation-Exchange-Capacity is low (3-4 $cmol_c/kg$), therefore the adsorption and buffer capacity for applied cations is low as well. The reserves of N, P, and Mg are low, while those of K are low to medium. Available P and K correspond with their reserves (1-3 ppm P, 60-100 ppm K).

2.2. Agronomic procedures

Using sites on an existing experiment station has the disadvantage of using sites which are no more "virgin" but have their specific history of land use. This includes probable effects of preceding crops and previous fertilizer applications. However, it is also assumed that the results of the first year of such a trial can be interpreted when taking those possible side effects into consideration (Table 1). While continuing with the experiment, these undesirable effects should be eliminated.

Plots at each site received the following treatments: 0 = no fertilizer application, P = 35 kg P/ha, N = 80 kg N/ha, and N+P = combined application of N and P. For the experimental design, a four x four Latin Square was used. The statistical analysis was done for each site separately and over all sites taking the sites as factor A and the fertilizer application as factor B.

The maize variety Composite 4 was planted on 8 row plots at a distance of 70 cm inter-row and 30 cm intra-row giving a plant density of approximately 48,000 plants per hectare. The seed was planted on the flat, ridging was done six weeks later. Nitrogen was applied as ammonium sulphate (40 kg/ha at planting, 40 kg/ha during ridging), and P as triple-super-phosphate was broadcast during soil preparation. For yield assessment, one row at both sides of each plot and the last plant at either end of each row were discarded.

History of the various sites (before 1988)

Tingoli: Several years under fallow; 1987 under short duration maize, low N doses (20 kg/ha)

Tolon: Several years under fallow

Nyankpala: Several years under maize/groundnut rotation; 1987 under short duration maize, N application only

Kumayili: Several years under maize, low to medium N, P, (K) doses

Kpalsawgu 1: Several years under maize; 1987 under rice (failed), no fertilizer application

Kpalsawgu 2: Several years under maize/yam, low to medium N and P doses

2.3. Analytical methods

2.3.1. Topsoils

The pH was measured in 0.01M $CaCl_2$. Available P was determined by the Bray-1-method. Checks for exchangeable Al were conducted with the Aluminon method, for exchangeable Zn by extraction with 0.5M $CaCl_2$ and determination of the element by means of atomic absorption spectrometry.

2.3.2. Plant material

At tasseling 12 ear leaves per plot were sampled at random, rinsed with tap water, then with deionized water and afterwards dried at a temperature of about 70°C. The dried leaves were then ground and analysed for the various nutrients. The same procedure was applied to the grain and stover samples. Parallel samples were dried at 105°C in order to be able to calculate nutrient concentrations and uptake on oven-dry basis. For N determination the Kjeldahl method was used. For other nutrients, material was ignited at 450-480°C in a muffle furnace overnight, the ash then neutralised with 10M HCl and heated in 0.5M HCl on a sandbath for 15 min. In the filtrate, P was determined by the molybdenum-blue-method, K by flame photometry; Ca, Mg, Cu and Zn by atomic absorption spectrometry.

In order to get an idea about the aeration status of the various sites during 1988 season, the water content was monitored by means of a neutron probe. Additionally, the N/Mn ratio in the maize was used to give additional information. This is the simplification of a method proposed by Glinski et al. (1989). The method is based on the fact that during decreasing redox potential, Mn is mobilized and taken up in comparatively larger amounts while N is behaving the opposite way. Since the mobility of Mn increases with decreasing pH, differences in pH have to be considered as well.

3.1. Results and discussion

3.1.1. Topsoils

Taking variation on each site and differences between sites of pH and available P as indicators for preceding ferti- lizer applications and the homogenity of the various sites, the pH values (Fig. 1) only indicate for Tolon and Nyankpala site some slight variability within their experimental plots (see %CV). Generally, there is a tenden- cy of decreasing pH downslope, which should be, however, the result of long-term soil formation and not of short-term land use. Although pH values below 5 are predominant at Kpalsawgu 1, no exchangeable Al was found in the topsoil

The pH levels in the topsoils of the upper and middle slope sites are all clearly above 5 and correspond with those found for similar sites (Hauffe, 1989). Therefore, application of heavy N doses (as ammonium sulphate) in recent times can be excluded on these sites. Otherwise acidification to pH values below 5 should be visible as it was found in a long-term trial on a Tingoli site (Hauffe, 1990).

The initial values for available P coincide more or less with the fertilizer application history. The values after P application are highly variable as indicated by the LSD values. They don't seem to follow a simple pH gradient (in this case Tolon should have the highest, Kpalsawgu 1 the lowest values), but are probably more determined by the quantity and/or activity of absorbing and fixing hydrated oxides of Fe and Al.

3.1.2. Nutrient concentration in ear leaf and grain

The ear leaf was selected for the investigation of the nutrient supply during crop growth. Both, N and P in the ear leaf (Fig. 2) are generally at the lower end of their optimum ranges (Finck, 1982). That explains the significant increase in N or P according to the treatments. The relatively low N level on Tolon site can be attributed to the long preceding fallow period. Usually, fallow reduces the microbial activity including N mineralisation (Wild, 1972). This should be eliminated in the third year of the experiment after grounduts have been culti-

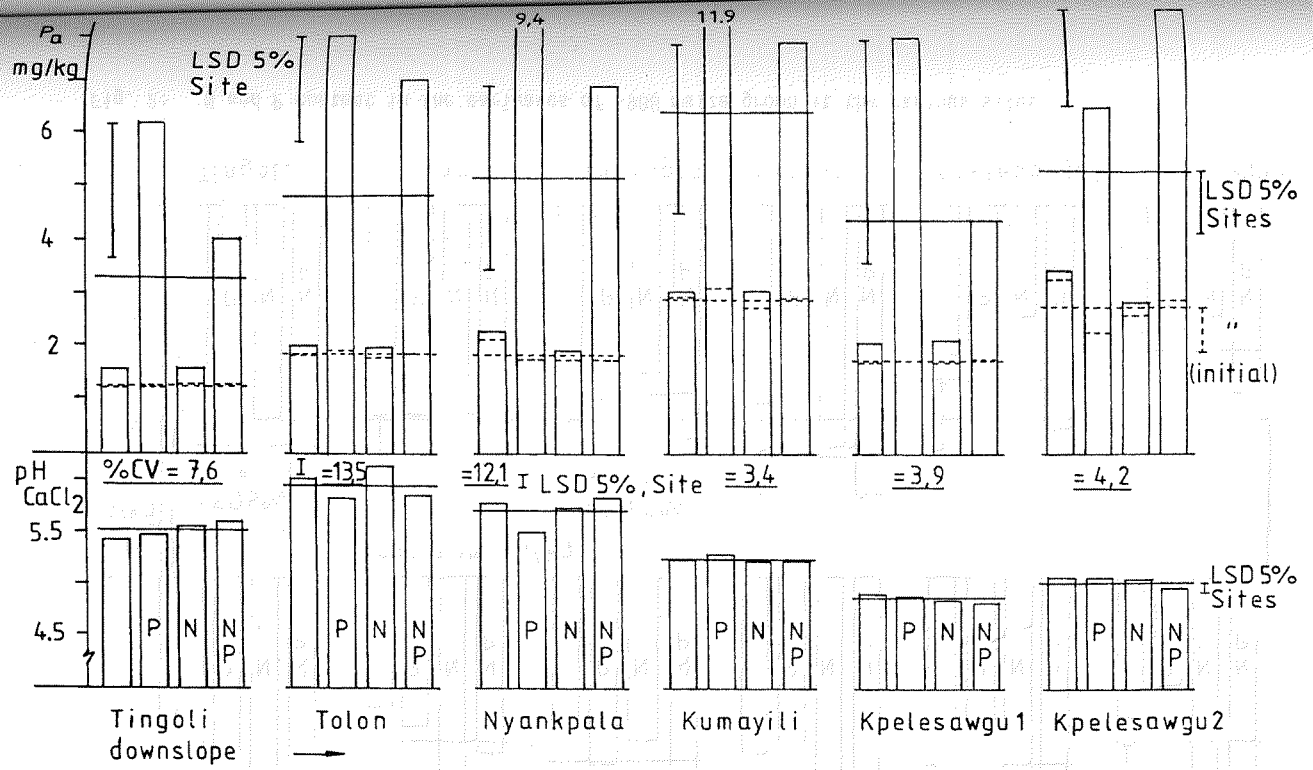

Fig. 1: Initial values of available P (Pa, mg/kg) and pHCaC12 and values at the end of 1988 growth period at the various sites

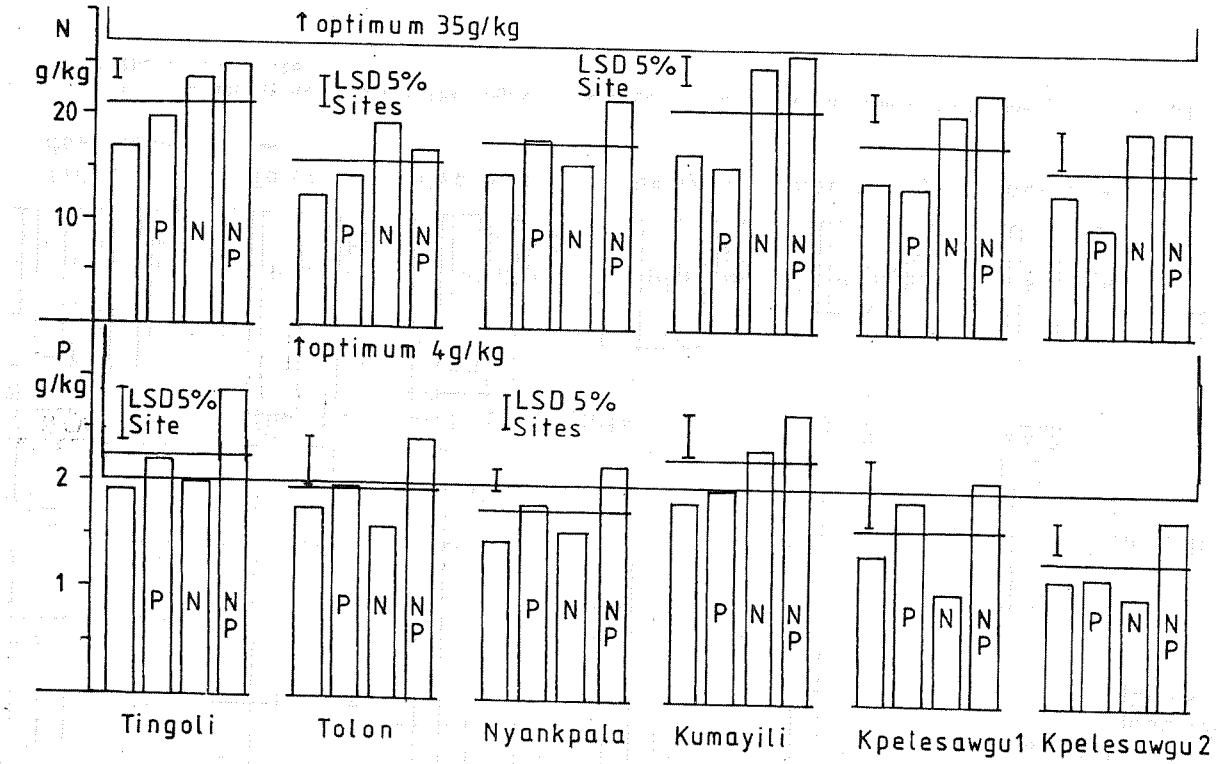

Fig. 2: N and P content in the earleaves of 1988 maize grown at the various sites

vated. Compared to the other treatments the combined application of N and P has resulted in significantly higher P concentrations (Table 1).

TABLE 1: SIGNIFICANCE (P = 0.05) OF VARIOUS MAIZE CROP CHARACTERS ACCORDING TO THE FOUR TREATMENTS AFTER ANALYSIS OVER ALL SITES.

N (g/kg) in earleaf			P (g/kg) in earleaf		
N P	22.5	a	N P	2.33	a
N	22.2	a	P	1.85	b
0	15.9	bc	0	1.60	cd
P	15.2	c	N	1.59	d

Cu (mg/kg) in earleaf			Zn (mg/kg) in earleaf		
N	5.79	a	N	26.2	a
N P	5.12	b	N P	23.2	ab
0	4.29	cd	0	22.6	bc
P	3.86	d	P	19.4	c

N (g/kg) in grain			P (g/kg) in grain		
N	17.5	a	P	3.99	a
N P	16.2	b	N P	3.87	a
0	15.5	cd	0	3.36	b
P	15.0	d	N	3.05	c

Cu (mg/kg) in grain			Zn (mg/kg) in grain		
N	2.91	a	N	33.4	a
0	2.72	ab	0	30.7	bcd
N P	2.46	bc	P	29.2	cd
P	2.27	c	N P	28.8	d

grain yield (Mg/ha)			stover yield (Mg/ha)		
N P	3.62	a	N P	4.44	a
P	1.72	bc	P	3.56	b
N	1.57	c	N	2.85	cd
0	1.11	d	0	2.45	d

N uptake (kg/ha)			P uptake (kg/ha)		
N P	81.3	a	N P	15.6	a
N	43.3	bc	P	8.4	b
P	42.3	c	N	5.9	cd
0	28.8	d	0	4.6	d

Unlike the ear leaves, nutrient concentrations in the grain (Fig. 3) were within the optimum range. However, nutrient content in the stover was still very low (N between 4 and 6 g/kg, P between 0.3 and 0.5 g/kg). While the N level

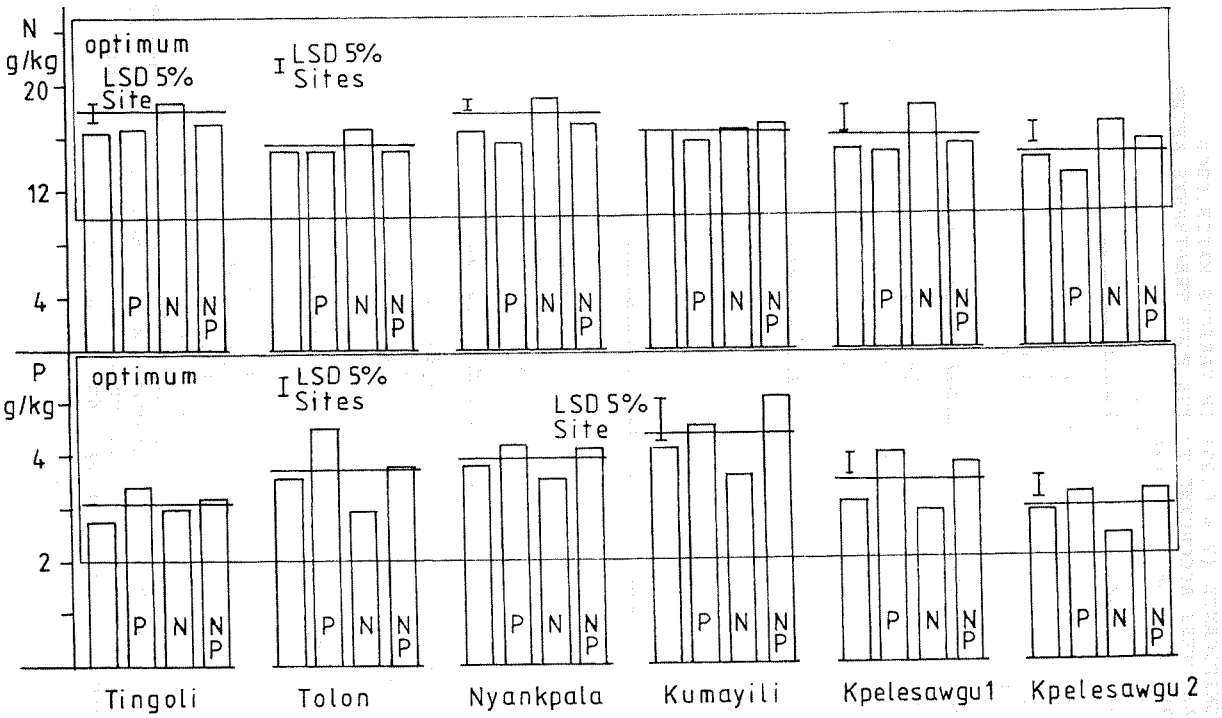

Fig. 3: N and P content in the grain of 1988 maize grown at the various sites

was more or less the same on all sites, P levels differed more, with Kumayili site having the highest level in the ear leaves. Generally, the application of N and P increased the content of the respective element (Table 1), but the increase was not always significant at the various sites (Fig. 3).

The K, Ca, and Mg concentrations were not affected by the treatments (data not presented). Their level in the ear leaves were (as for N and P) at the lower end of the optimum ranges (Table 2) but (besides Ca) within or even above (K) the ranges indicated for grain.

TABLE 2: POTASSIUM, CA, AND MG CONTENT (G/KG) IN EARLEAF AND GRAIN OF MAIZE GROWN ON SIX DIFFERENT SITES

		earleaf	grain
K	actual	12 - 18	5.1 - 9.6
	optimum	17 - 25	2 - 4
Ca	actual	2.9 - 4.3	0.021 - 0.034
	optimum	4 - 10	0.1 - 0.2
Mg	actual	1.7 - 2.8	1.27 - 1.83
	optimum	2 - 4	1 - 2

What was found for the other elements can also be stated for the trace elements Cu and Zn (Fig.4 and Fig.5). Only Nyankpala site (especially for Zn) had higher values. However, there is no explanation for its divergent behaviour (e.g. checks for exchangeable Zn did not show any differentiation among the sites). Nitrogen application (alone and for Zn also in combination with P) increased the levels of Zn and Cu (Fig. 4 and Table 1). This might be the result of a mobilization effect due to initial acidification by ammonium sulphate observed in another rotation trial (Hauffe, 1990). On the other hand, P application alone depressed the already low values even more (Fig. 4 and Table 1). The increased levels of the two elements observed in the ear leaf at Nyankpala site were again detected in the grain (Fig. 5) as well as the mobilizing effect of the applied N and the opposite effect of the P. The interaction effect of Zn with P is well documented, however usually at much higher P doses (Loneragan et al., 1979), but nothing is stated for Cu in the literature (e.g. Marschner, 1986). However, similar interactions observed for Zn can be assumed for Cu.

3.1.3 Grain and stover yield

Application of N and P increased grain yields significantly at all sites (Fig. 6), while the single nutrient treatments did not always perform better than the zero treatment. However,

Fig 4:

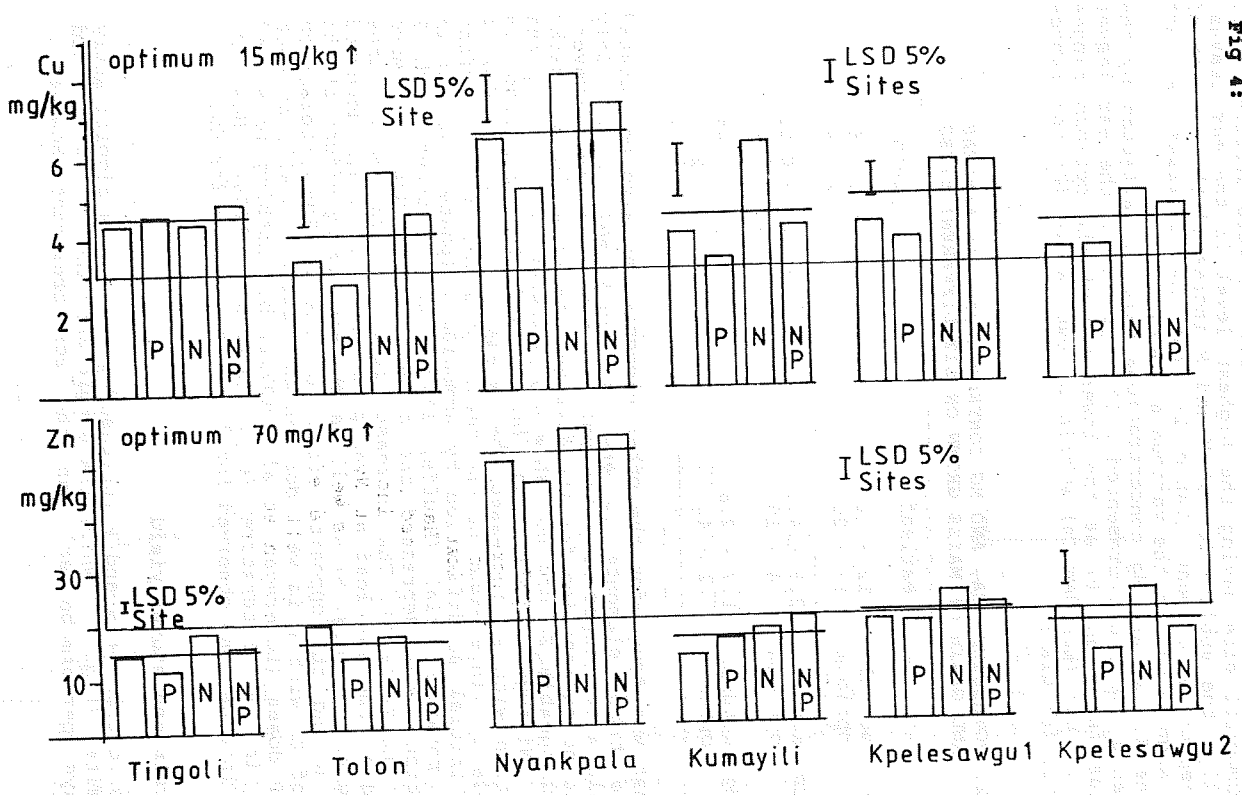

Fig. 4: Cu and Zn content in the earleaves of 1988 maize grown at the various sites

Fig 5:

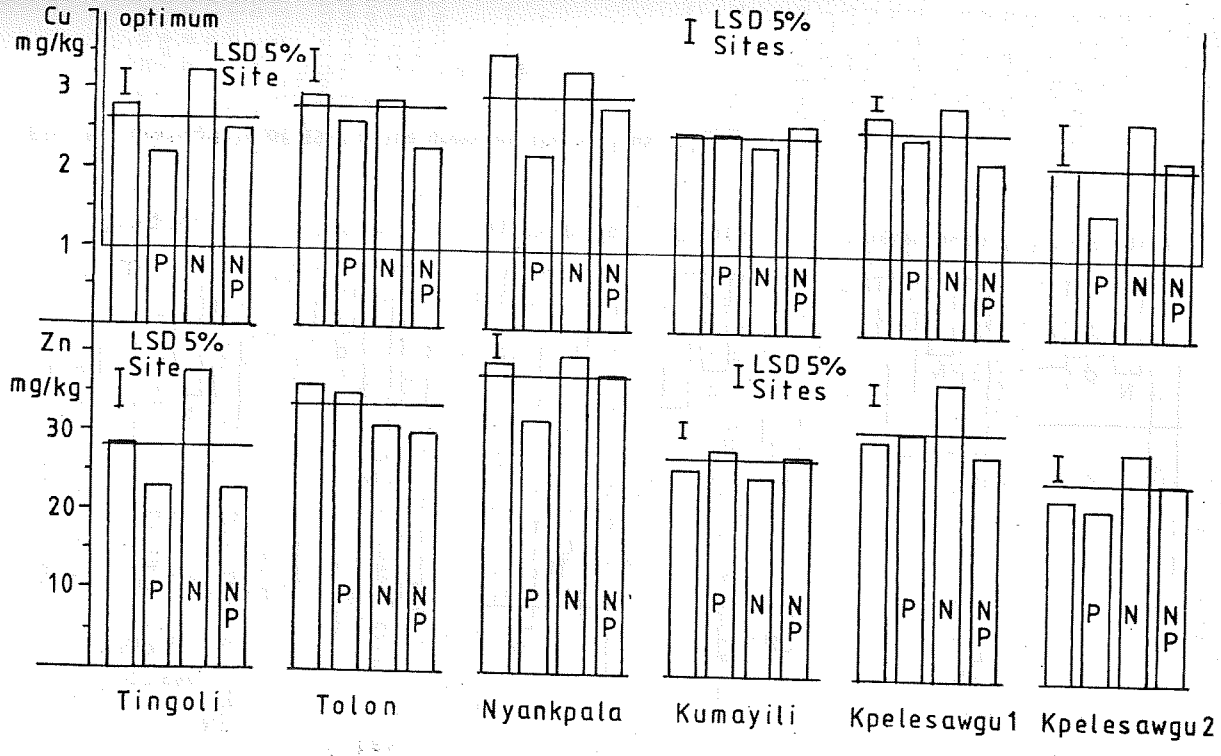

Fig. 5: Cu and Zn content in the grain of 1988 maize grown at the various sites

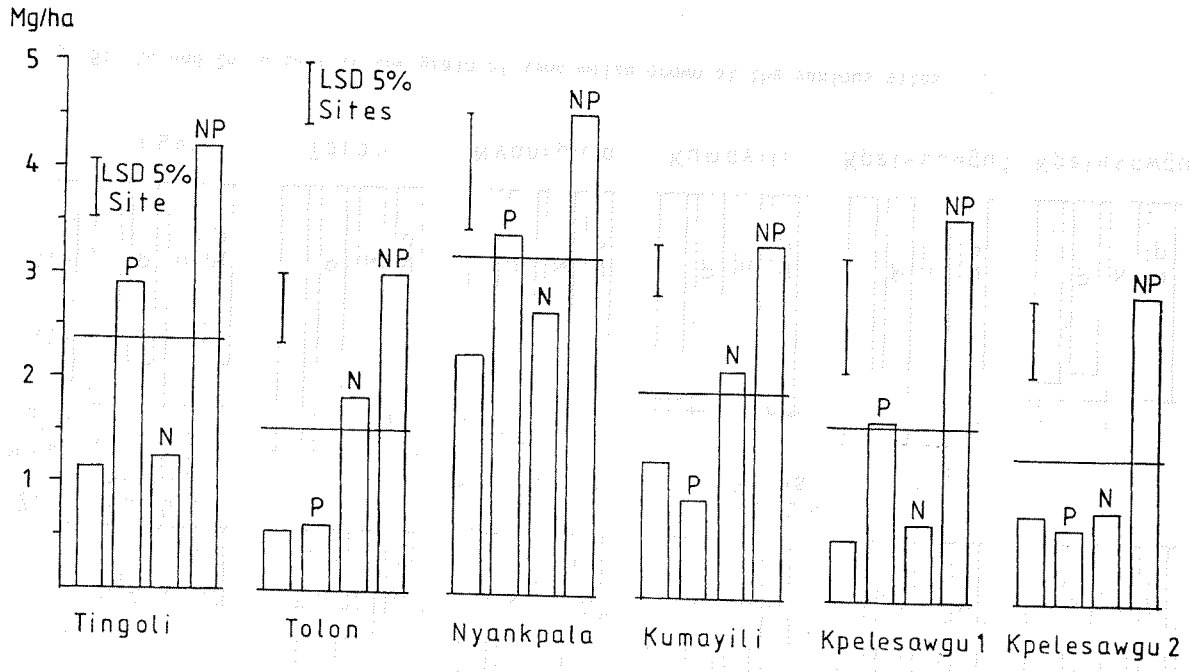

Fig. 6: Grain yield of 1988 maize grown at the various sites

treatment. However, when analysed over all sites, the single nutrient effects were significantly different from the control but still without significant differences among themselves (Table 1). Growing conditions in 1988 were favourable (fairly wet) and mean grain yields of 3.0 to 4.7 Mg/ha can be considered as good.

The affordable fertilizer rates used by the farmers would most probably be much lower than the levels used in the trial. For maize production in the Upper Regions, Runge-Metzger (1990) reported that farmers apply only 28 kg N/ha when estimated from a production function analysis.

Whether the much better Zn supply on Nyankpala site has contributed to the outstanding high yield on this site cannot be answered by the data. However, there are indications that Zn application can increase maize yields on these upland sites (E. Frey, NAES unpublished data; Edmeades, 1984).

The observed actual water and air volume (data not presented) during 1988 rainy season indicated pronounced suffocation periods for the two lower slope sites. This is confirmed by the fact that the N/Mn ratio in the maize plants on these two sites was significantly lower than on the others (Table 3). However, the low pH values (Fig. 1) might have contributed to it.

TABLE 3: NITROGEN-MANGANESE (N/MN) RATIO IN WHOLE MAIZE PLANTS AT HARVEST

	N/Mn	
Nyankpala	270	a
Tolon	207	a
Tingoli	195	a
Kumayili	185	a
Kpalsawgu 1	104	bc
Kpalsawgu 2	87	c

As expected, the yield levels along the catena shifted from year to year according to the quantity and distribution of the rains. These observations support those of Moormann and Kang (1978) that crops will benefit in wet years from the generally better drainage of the plateau and upper slope sites and, in dry years, from the better water supply on the lower slope positions provided the nutrient supply (mainly N and P) is adequate.

Unlike the grain, stover yields did not differ among sites (Fig. 7). The combined effect of N+P treatment was not superior to the P treatment at some sites. At least for the two lower slope sites, this finding was attributed to lower N mineralisation and, therefore, less N supply to maize plants (see also N in earleaf, Fig. 2). However, when analysed over all sites, P application resulted in a higher increase of stover than N application.

Fig 7

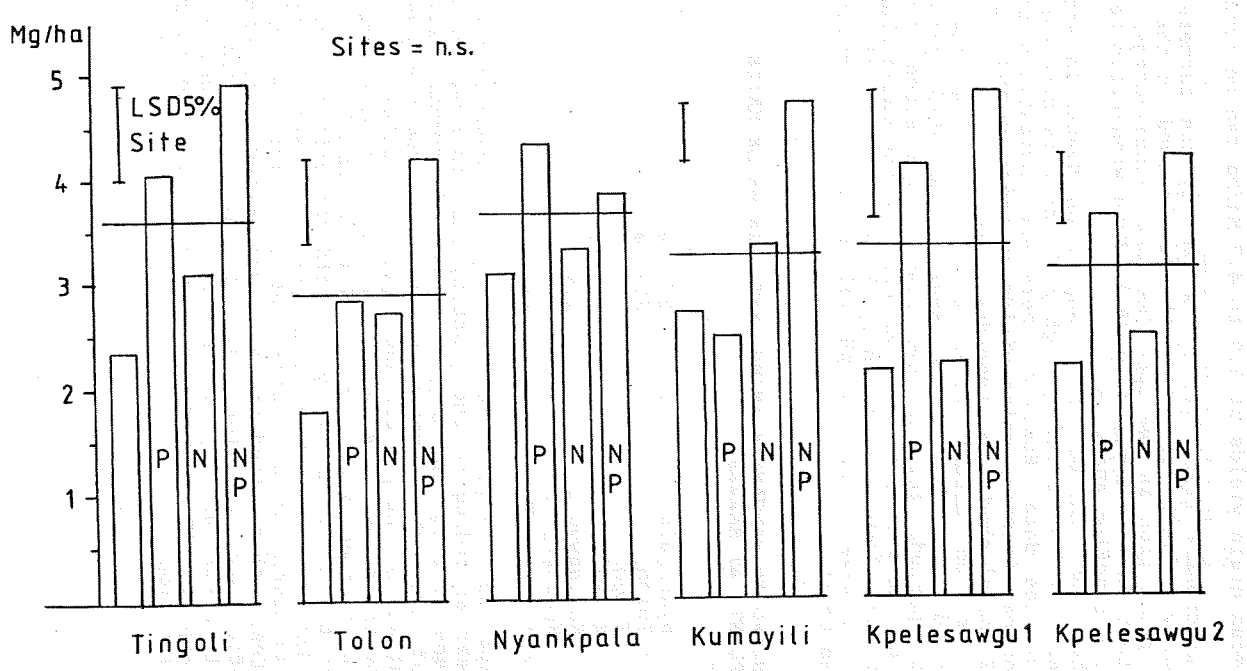

Fig. 7: Stover yield of 1988 maize grown at the various sites

Fig 8.

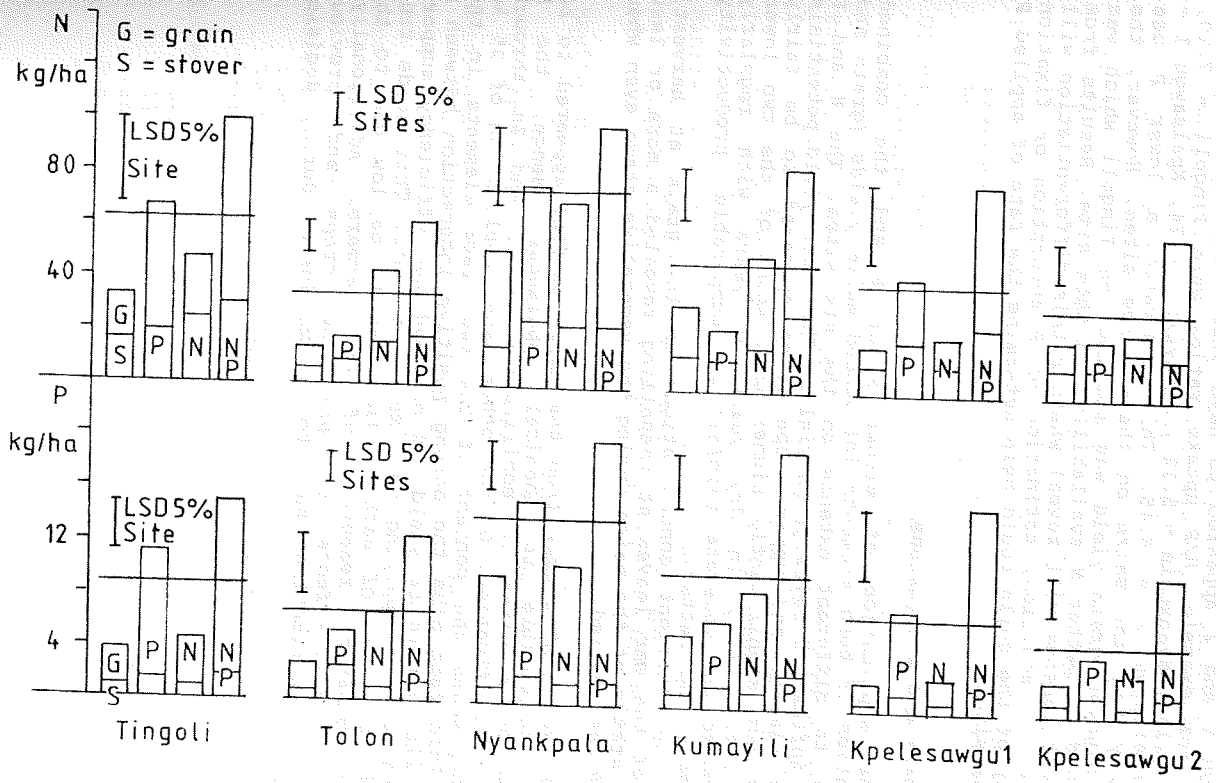

Fig. 8: N and P uptake by stover and grain of 1988 maize grown at the various sites

3.1.4 N and P uptake

The uptake of N and P by maize plants decreased downslope (Fig. 8). Comparing the uptake among the sites, Tingoli and Kpalsawgu 1 and 2 appeared to have less available P than the others. For example, N/P uptake ratios were Tingoli = 7.10, Tolon = 5.16 , Nyankpala = 5.32 , Kumayili = 4.74, Kpalsawgu 1 = 5.80, Kpalsagwu 2 = 6.45. This indicated a lower P use efficiency by the maize on these three sites. However, the second highest grain yield was obtained on Tingoli which was attributed to better N availability on this site. Results from subsequent seasons will reveal whether this differentiation will continue. In addition, estimation of P absorption or fixation capacity of the soils could help determine the fate of applied P at these sites.

4. Summary and conclusions

The application of either N or P and the combined application of both elements influenced maize yields (grain and stover) to different extents on the six sites. The N and P uptake influenced maize grain yields. The grain yield potentials of the plateau and upper slope sites appeared to be fairly similar but significantly higher than those of the two lower slope sites. Only in dry years or years with regularly distributed and moderate rainfall was comparable productivity observed on the latter.
Unlike the nutrient concentrations in the grain at harvest, those of the ear leaves at tasselling revealed a more or less hunger status of the maize during the vegetative stage even when N and P was applied.

The nutrient supply from the soils studied appeared to be fairly susceptible to chemical imbalances. Hence, the N application resulted in mobilization of Cu and Zn through initial acidification. On the other hand, application of 35 kg P/ha depressed the content of the two trace elements in the crop. This fact plus the strong positive interaction between N and P with regard to yield and nutrient use efficiency support the argument of applying both main nutrients. This holds true even if the dose of each of them has to be low due to the limited monetary resources of the farmers. Additionally, possible after-effects of preceding crops and previous fertilizer applications have to be considered during decision making.

Literature

Adu, S.V. 1957. Report on the detailed soil survey of the Central Agricultural Station Nyankpala, Dagomba District, Northern Region, Technical Report No. 28. Soil research Institute, Kumasi.

Edmeades, G.O. 1984. On-Farm Agronomy Research 1984. Ghana National Maize Workshop, summarized Proceedings 1981-1984, pp. 67-74 Ghana Grains Development Project, Kumasi.

Finck, A. 1982. Fertilizers and Fertilization. Introduction and practical guide to crop fertilization. Verlag Chemie, Weinheim, Deerfield Beach, Basel.

Glinski, J., Schlichting, E. and Stepniewska, Z. 1989. Characterization of the soil aeration status by plant and soil analyses. Z. Pflanzenernaehr. Bodenk., 152, pp.27-32.

Haerdter, R. 1989. Utilization of nitrogen and phosphorus by intercropping and sole cropping systems of maize (Zea mays, L.) and cowpea (Vigna unguiculata L.) on an alfisol in northern Ghana. Nyankpala Agricultural Research Report No.5, NAES.

Hauffe, H.-K. 1989. Site characterization of the West Ridge Upland Experiment Area (NAES). In: Nyankpala Agricultural Research Report No.6, Annual Report 1987/88, NAES, pp. 139 - 154.

Hauffe, H.-K. 1990. Nutrient availability to maize after various crop sequences (Crop sequence trial of 1981). In: Nyankpala Agricultural Research Report No.7, Annual Report 1988, NAES (in press).

Loneragan, J.F., T.S. Grove, A.D. Robson, and K. Snowball. 1979. Phosphorus toxicity as a factor in zinc-phosphorus interactions in plants. Soil Sci. Soc. Am. J. 43: 966-972.

Marschner, H. 1986. Mineral nutrition in higher plants. Academic Press, London, San Diego.

Moormann, F.R. and B.T. Kang. 1978. Microvariability of soils in the tropics and its agronomic implications with special reference to West Africa. In: Diversity of soils in the tropics. ASA Special Publication Number 34: 29 - 44.

Runge-Metzger, A. 1990. Farm-household decision making with respect to the adoption of agricultural innovations - a village level case study in the Upper Regions. Paper presented at the 2nd National Workshop on Improving Farming Systems in the Savanna Zone of Ghana, 24th - 26th April, 1990.

Schmidt,G. and E. Frey. 1988. Crop rotation effects in savanna soil. Nyankpala Agricultural Research Report No. 4, NAES.

Sipkens, L. 1990. On-farm experimentation. In: Nyankpala Agricultural Research Report No.7, Annual Report 1988, NAES (in press).

Wild, A. 1972. Mineralisation of soil nitrogen at a savanna site in Nigeria. Expl. Agric. 8: 91- 97.

Discussion

A. OSAFO

Can't the experiment be continued with sorghum?

H. -K. HAUFFE

In 1990, the sites will be cropped again with maize in order to measure the first year of rotation effects. In 1991, there should again be a legume to maintain the cereal/legume rotation, but in 1992, sorghum could be the test crop.

KWAKYE (UCC)

COMMENT. You showed variations in reaction of the soils on the catena and so the nutrient concentrations and uptake by maize were variable. It may be advisable to look at the relationship between soil pH and the nutrient concentrations and uptake particularly for the micronutrients.

H -K. HAUFFE

This proposal is well taken and the possible relationship will be considered when interpreting the results.

D.K. ACQUAYE

Did you find any signs or symptoms of manganese toxicity? The high concentration of manganese in the plant as one goes fron the upper to the lower slope soils in the catena may be due to high water content bringing about reduced conditions and therefore increased availability of manganese.

H -K. HAUFFE

No, the plants didn't show any signs of Mn toxicity.

P. SALEZ

Your 6 locations differ by two factors: place in the toposequence and cultural history. I'm afraid that in your layout study, it will be difficult to separate these two different factor effects on your yields and mineral status evolution for your soils.

H -K. HAUFFE

This applies especially for the first and may be also for the second year, but those effects should be eliminated after that.

EFFECT OF SOURCES OF NITROGEN AND LIMING RATES ON LATE MILLET (PENNISETUM TYPHOIDES) IN ACID SAVANNA SOIL

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Soil Research Institute
Council For Scientific and Industrial Research

Introduction

The adverse effect of low soil pH on the yield of most crops has been recognised and this has prompted the need for a liming programme to be drawn or the establishment of a suitable source of nitrogen that will not only give high crop yield but maintain a fairly good soil pH with time. The ammonium ion (NH^+_4) causes a drastic reduction in soil pH when compared to the nitrate ion (NO^-_3) while urea initially tends to increase the soil pH (Patrie and Jackson, 1984).

Using three sources of nitrogen (Urea, Sulphate of ammonia and Calcium ammonium nitrate) at Manga on three varieties of guinea corn it was found that there was no varietal differences but nitrogen gave a very high yield increase (S.R.I., 1970). The different sources of nitrogen gave similar yields. Rani et al. (1980) observed that fertilizer increased grain yield up to 60 kg N/ha and 20 kg P_2O_5/ha while potassium application had no effect on grain yield. At Vea, Bolgatanga, split application of 134 kg N/ha, half at planting and half at tillering gave high yield of paddy rice (S.R.I., 1978).

Smiley (1974) observed that the major factor influencing the rhizosphere pH (pHr) was the form of nitrogen supplied to the roots. The pHr was generally lower than the non-rhizosphere pH where $NH4^+$ was supplied, higher where NO^-_3 was used, and relatively unchanged where both were added. Working on maize, Ofori (1971) noticed that liming at 0.5 t/ha and 1.0 t/ha gave significant higher yield over unlimed treatment. In a liming and phosphorus experiment, Lathwell (1979) reported that though the lime-phosphorus interaction was not positive, there were responses to both lime and phosphorus independently. Exchangeable aluminium was not a factor in reponse to liming, and yield increases were attributed to increase in phosphorus availability.

The importance of acid soils is gradually gaining grounds in Ghana and needs serious attention. These generally occur in high rainfall areas, especially in the Western Region, due to severe leaching and in valley bottoms. Acid soils also occur at some areas due to agronomic practices such as continuous and/or intensive cultivation resulting in serious leaching and erosion and the utilization of ammonium fertilizer, eg. sulphate of ammonia. Recently, acid soil problems have been encounted in some places including Aiyinase, Manga, Ghana Seed Company at Asuoyeboa, Central Agricultural Station trial fields and Soil Research Management Farm.

In this paper the effects of different sources of nitrogen and three levels of lime on millet are presented.

Procedure

The experiment was started at Manga in June 1986. The initial soil pH range of the experimental area was 4.5 to 6.5.

A split-plot design with four replications was used. Five different sources of nitrogen viz: Control, Urea, Sulphate of ammonia (SA), Calcium Ammonium Nitrate (CAN) and Cowdung were used. For the three inorganic fertilizers, 70 kg N/ha was used, applied at 1/3 at planting and the remaining 2/3 5 weeks after planting whilst 500 kg/ha cowdung (organic) was used. Three lime levels were employed viz:- Control (no Lime), 0.5 t/ha and 1.0 t/ha. Cowdung and lime were broadcast and hoed in two weeks before planting. With the exception of cowdung, all the other treatments received 30 kg K_2O/ha as Muriate of potash and 50 kg P_2O_5/ha as triple superphosphate at planting. Plot size was 4m x 3m and planting distances were 75 cm x 25 cm. This gave a plant population of approximately 105,000/ha (two plants/hill)

Soil and plant samples were taken at appropriate points of the experiment and analysed for pH, P and K. Plant heights and tiller formation were observed sixty days after planting. The plants were harvested at maturity and grain yield reported as kg/ha.

Results and Discussions

Liming did not influence soil pH significantly in 1986 (Table 1). The difference between the initial soil pH and final soil pH were zero lime = 0.6, 0.5 t/ha lime = 0.8 and 1.0 t/ha lime = 1.2. In a similar experiment, Bertic et al. (1989) reported an increase of 2.39 units with hydrated lime at 20 t/ha. In 1987, lime was not effective in improving soil pH when compared to no lime (Table 2). This was attributed to the initial high soil pH for the lime treatment due to the residual effect of the previous lime. With the addition of more lime in 1988, liming resulted in better improvement of the soil pH than zero lime. Zero lime, 0.5t/ha lime, 1.0 t/ha lime gave an increase in soil pH over the initial by 0.1, 0.4 and 0.7 units, respectively (Table 3). The initial soil pH for the subsequent years was high resulting in no observable effect of lime on soil pH (Tables 4 and 5).

TABLE 1: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON SOIL PH AT MANGA, 1986

Treatment	No lime (control) Days after Trt. Appl				0.5 t/ha Lime Days of Trt. Appl.				1.0 t/ha Lime Days after Trt. Appl.			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	5.1	6.2	5.6	6.0	5.6	6.2	5.6	6.5	5.7	6.7	6.1	6.4
Urea	5.3	6.0	5.5	5.9	5.3	6.7	5.6	6.4	5.4	6.4	5.9	6.6
SA	5.6	5.5	5.2	5.4	5.4	6.4	5.6	6.1	5.4	7.0	6.2	6.6
CAN	5.4	6.0	5.4	6.3	5.3	6.2	5.6	6.0	5.5	6.7	6.0	6.7
Cowdung	5.7	6.2	5.6	6.4	5.6	6.6	5.8	6.2	5.5	6.7	6.0	6.4
Mean	5.4	6.0	5.5	6.0	5.4	6.4	5.6	6.2	5.3	6.8	6.0	6.5

TABLE 2: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON SOIL PH AT MANGA, 1987

Treatment	No Lime Days after Trt. Application				0.5 t/ha Lime Days after Trt. Application				1.0 t/ha Lime Days after Trt. Application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	5.5	5.7	5.4	5.7	6.0	5.7	5.7	6.0	6.3	5.8	5.9	6.3
Urea	5.3	5.9	5.3	5.7	6.1	5.5	5.7	6.2	6.3	5.9	6.0	6.4
SA	5.4	5.4	5.2	5.3	6.1	5.8	5.5	5.7	6.4	6.0	5.9	6.2
CAN	5.3	5.5	5.4	5.8	5.9	5.9	5.7	6.0	6.3	6.1	6.0	6.4
Cowdung	5.4	5.5	5.4	5.8	6.2	5.8	5.7	6.3	6.4	6.1	5.9	6.5
Mean	5.4	5.6	5.3	5.7	6.1	5.7	5.7	6.0	6.3	6.0	5.9	6.4

Table 1 and Table 2

TABLE 3: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON SOIL PH AT MANGA, 1988

Treatment	No Lime Days after Trt. Application				0.5 t/ha Lime Days after Trt. Application				1.0 t/ha Lime Days after Trt. Application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	5.8	5.7	5.9	5.9	6.0	5.8	6.1	6.3	6.2	6.1	6.3	6.9
Urea	5.3	5.8	5.6	5.5	6.1	6.0	6.2	6.5	6.3	6.2	6.4	6.9
SA	5.3	5.3	5.2	5.2	5.9	5.8	6.0	6.3	6.2	6.1	6.3	6.9
CAN	5.5	5.4	5.5	5.6	6.1	6.0	6.4	6.6	6.3	6.2	6.4	7.0
Cowdung	5.5	5.6	5.5	5.6	6.3	6.1	6.3	6.9	6.4	6.3	6.5	7.0
Mean	5.5	5.6	5.5	5.6	6.1	5.9	6.2	6.5	6.3	6.2	6.4	7.0

TABLE 4: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE PHOSHPORUS AT MANGA, 1987.

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	15	24	29	21	7	23	25	27	11	25	20	18
Urea	10	25	21	21	7	23	21	21	10	21	20	19
SA	9	19	18	20	10	22	16	20	9	28	23	45
CAN	12	24	18	16	8	19	21	17	11	24	17	18
Cowdung	7	23	13	13	6	15	17	12	8	20	22	19
Mean	31	23	26	18	32	25	47	19	30	22	40	18

TABLE 5: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE PHOSPHORUS AT MANGA, 1988.

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	12	28	32	20	11	29	28	25	13	26	22	19
Urea	15	29	27	22	13	30	29	20	14	22	21	20
SA	11	22	25	19	12	25	18	17	10	28	25	21
CAN	13	27	22	15	12	21	25	18	12	25	24	20
Cowdung	10	24	18	12	9	18	22	20	11	26	27	25
Mean	12	26	25	18	11	25	24	20	12	25	24	21

TABLE 6: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE PHOSPHURS AT MANGA, 1986

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	42	27	33	24	35	23	35	25	29	17	43	18
Urea	28	21	30	15	31	27	44	27	28	24	41	17
SA	31	26	20	18	28	23	50	16	23	16	36	14
CAN	30	24	26	19	32	26	52	18	35	28	53	21
Cowdung	25	18	32	11	33	27	56	12	37	26	44	19
Mean	31	23	26	18	32	25	47	19	30	22	40	18

Differences between the nitrogen treatments for soil pH were not significant.

These results do not support those of Patrie Jackson (1984) who observed an increase in soil pH due to Urea and a decrease due to SA application.

Lime had no significant effect on available phosphorus, but increases in available phosphorus were observed nine weeks after treatment application in 1986 (Table 4). This may be due to the neutralization of H^+ and/or aluminium with the subsequent release of phosphorus. All the nitrogen treatments did not significantly affect available phosphorus. In 1986, under lime treatment, all the N treatments gave the highest available phosphorus nine weeks after treatment application, this was olso for Urea and cowdung when lime was not applied (Table 6). When lime was not applied, SA was less effective in releasing phosphorus as compared to Urea and CAN. This is possible due to the fact that SA has an acidifying effect resulting in fixation of available phosphorus. For 1987 and 1988 there was a general increase in available phophorus at three and nine weeks after treatment application and a fall at harvest due to uptake.

The effects of liming on available potassium for the three years were not statistically significant (Table 7, 8, 9). Nitrogen treatments also gave no significant effect on available potassium three or nine weeks after treatment application but there was a subsequent fall at harvest due to uptake by plants.

The effect of liming on tillering was not significant. Tillering habit of plants apparently enables them to fully exploit the environment particularly where seeding rate is low or plant establishment is poor. In this experiment, the effect of nitrogen on tiller formation is consistently clear for the first two years except in 1988 and 1989 (Table 10). This supports the findings of Reddy et al. (1987) who established that nitrogen fertilization resulted in increased number of tillers/hill. This is probably due to adequate nutrient supply that allows production of new shoots. Urea and SA were more consistent in producing more tillers followed by CAN.

The effect of nutrition on the size of the plants was clearly established in this experiment (Table 11). The nitrogen treatments, Urea, SA and CAN gave plants which were significantly taller than those from control and cowdung treatments in the first two years.

TABLE 7: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE POTASSIUM AT MANGA, 1986.

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	59	72	38	35	56	67	59	47	60	56	61	50
Urea	60	79	44	40	59	51	57	48	72	53	58	50
SA	64	68	42	49	56	86	48	52	49	62	58	49
CAN	66	65	51	36	61	57	66	41	39	56	56	51
Cowdung	56	71	55	43	59	76	57	51	49	66	66	60
Mean	61	71	46	41	58	67	58	48	54	59	60	52

TABLE 8: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE POTASSIUM AT MANGA, 1987.

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	76	116	118	77	98	165	211	121	71	96	99	54
Urea	99	98	95	64	87	222	179	96	84	94	75	53
SA	111	104	89	48	85	154	133	87	96	105	72	48
CAN	75	95	98	66	93	193	181	83	75	102	77	46
Cowdung	78	87	97	57	75	160	189	89	76	93	81	49
Mean	88	100	99	62	86	179	179	95	80	98	81	50

TABLE 9: EFFECTS OF LIMING AND N-FERTILIZER APPLICATION ON AVAILABLE POTASSIUM AT MANGA, 1988

Treatment	No Lime Days after Trt. application				0.5 t/ha Lime Days after Trt. application				1.0 t/ha Lime Days after Trt. application			
	0	21	63	164	0	21	63	164	0	21	63	164
Control	80	108	115	78	102	172	205	132	72	89	92	62
Urea	89	102	101	69	85	250	182	103	88	92	85	43
SA	105	109	94	54	89	128	134	92	92	110	78	52
CAN	80	98	102	68	85	172	180	99	79	112	92	74
Cowdung	79	82	104	59	80	108	126	94	76	102	89	52
Mean	81	100	103	66	88	166	165	104	81	101	87	57

TABLE 10: EFFECTS OF LIMING AND N FERTILIZER APPLICATION ON NUMBER* OF TILLERS PER PLANT IN LATE MILLET AT MANGA.

LIME RATES	TREATMENTS	1986	1987	1988	1989
0 t/ha	Control	7.9	7.3	6.9	4.4
	Urea	10.7	9.5	9.1	5.4
	SA	10.4	8.7	7.7	5.1
	CAN	10.0	9.5	7.5	4.9
	Cowdung	7.7	8.1	7.4	5.1
	Lime Mean	9.6	8.6	7.7	4.9
0.5 t/ha	Control	8.3	7.9	6.5	4.8
	Urea	10.3	9.7	8.2	4.7
	SA	9.1	9.2	7.8	4.3
	CAN	9.0	9.4	6.1	4.7
	Cowdung	8.0	9.1	6.8	5.1
	Lime Mean	8.9	9.1	7.1	4.7
1.0 t/ha	Control	8.6	8.4	6.7	5.3
	Urea	10.0	8.5	8.3	5.1
	SA	10.0	8.9	8.4	5.9
	CAN	9.9	8.7	7.1	4.2
	Cowdung	7.6	7.3	6.6	4.9
	Lime Mean	9.2	8.4	7.4	5.1
LSD N-Treatment	5%	1.1	1.3	0.9	ns
	1%	1.7	ns	1.2	ns
C V %		14	12	23	21

Lime Treatment was not significant.
* 8 weeks after planting; Mean of four replications

In 1988, CAN performed similarly as control and cowdung. In 1989 the performance of SA was similar to control and CAN when no lime was applied. Similarly, Urea performed relatively poorly under 1.0 t/ha lime. This underlines the fact that while SA application needs intermittent liming, Urea application needs little or no lime application for good plant performance. Availability of nutrients to the plants, especially nitrogen, was probably the sole factor in determining the heights of the plants. Liming had no significant effect on plant height (Table 11).

TABLE 11: EFFECTS OF LIMING AND N FERTILIZER APPLICATION ON HEIGHT* (CM) OF LATE MILLET AT MANGA.

LIME RATES	TREATMENTS	1986	1987	1988	1989
0 t/ha	Control	42	42	42	63
	Urea	71	69	84	72
	SA	68	78	81	65
	CAN	72	57	48	65
	Cowdung	38	48	36	52
	Lime Mean	58	59	58	63
0.5 t/ha	Control	45	48	40	55
	Urea	81	88	75	72
	SA	64	77	73	71
	CAN	72	74	52	65
	Cowdung	38	42	43	51
	Lime Mean	60	66	57	63
1.0 t/ha	Control	42	51	49	59
	Urea	78	84	71	65
	SA	67	89	79	71
	CAN	62	85	54	58
	Cowdung	44	36	39	53
	Lime Mean	59	69	54	611
LSD N-Treatment	5%	3	8	8	4
	1%	5	11	11	6
C V %		7%	16%	10%	8%

Lime treatment was not significant.
* Mean of four replications

For the period covered by the experiment, liming did not affect grain yield probably because the soil pH range of the area during the experiment was not critically low for the normal growth of the plants (Table 12). The average grain yield for the four years running show that while grain yield due to control, Urea, CAN and cowdung fell with liming that of SA was highest at 1.0 t/ha lime.

Nitrogen had a significant effect on grain yield for the four years running (Table 12). According to Goldsworthy and Taylor (1970), sorghum plants that received sufficient nutrients were bigger with bigger heads, and subsequently resulted in high grain yield than the smaller ones. The available phosphorus and potassium range for the period of the experiment were 6 - 53 ppm P and 36 - 250 ppm K. These values were adequate for the growth of the crop and it was probably nitrogen which was limiting.

TABLE 12: EFFECTS OF LIMING AND N FERTILIZER APPLICATION ON GRAIN YIELD* (KG/HA) AT MANGA.

LIME RATES	TREATMENTS	1986	1987	1988	1989
0 t/ha	Control	1205	691	623	933
	Urea	1557	1234	1177	1852
	SA	1238	1281	1205	1800
	CAN	1396	1023	853	895
	Cowdung	1386	757	581	605
	Lime Mean	1358	997	893	1217
0.5 t/ha	Control	1033	762	500	653
	Urea	1286	1272	1157	1205
	SA	1562	1062	1248	1407
	CAN	1419	986	672	748
	Cowdung	991	834	567	557
	Lime Mean	1258	983	829	914
1.0 t/ha	Control	986	729	553	595
	Urea	1427	900	1241	1400
	SA	1658	1305	1172	1605
	CAN	1229	1248	515	567
	Cowdung	986	581	605	395
	Lime Mean	1257	953	817	912
LSD N-Treatment	5%	489	206	172	89
	1%	ns	275	230	119
C V %		22	25	25	11
LSD (lime 5%)		ns	ns	ns	170

* Mean of four replications

The effect of nitrogen on millet has been investigated by many workers. Application of nitrogen on finger millet grown on a sandy soil increased the number of fingers per panicle, 1000 - grain weight and grain yield (Reddy et al., 1987). According to Kaushik and Gautam (1988), N and P affected the production potential of pearl millet - cowpea or green gram intercropping system. They observed that pearl millet responded up to 60 kg N/ha and intercrop up to 30 kg N/ha and that P application did not improve the growth and yield of pearl millet. In another experiment, Rani et al. (1989) studied the effect of organic and inorganic nutrients on finger millet and found that fertilizer increased grain yield up to 60 kg N/ha and 20 kg P_2O_5/ha while K appliction had no effect on grain yield. They further stated that inorganic fertilizer use efficiency, recovery and economy were optimum at lower application levels, while organic nutrients showed such effects only at higher levels. In the present experiment, application of nitrogen at 70 kg/ha resulted in significant increases in tiller formation, plant height and grain yield of pearl millet. Urea and SA were more consistent in giving higher grain yields than control and cowdung. CAN became

less effective after the second year. Control and cowdung performed similarly throughout the experiment (Table 12). The availability of adequate nutrients (P and K) leaves nitrogen as the sole determinant of grain yield during the course of the experiment. The inability of cowdung (organic fertilizer) to perform similarly as the inorganic fertilizers was due to the fact that it was applied at very low rates and its accumulation over the years was probably inadequate to result in yield increases.

Conclusion

Liming may be necessary in improving the pH of acid soils. To ensure adequate release of plant nutrients and to avoid the possibility of over-liming, liming at 0.5 t/ha should be considered.

With the application of Urea or calcium ammonium nitrate or in the absence of fertilization, liming should not be done unless the soil pH level is critical (4.5 and below). With the continuous use of sulphate of ammonia, the soil pH should be analysed seasonally and liming done when the soil pH is below 5.

Where soil pH is a problem the use of Urea or Calcium ammonium nitrate should be considered.

Literature cited

Bertic, B., Vukadinovie, V., Kovacevic, U. and I. Juric. 1980. Influence of liming on soil acidity and iron availability. Soils and Fertilizers. Vol.52 No. 2.

Kaushik, S.K. and R.C. Gautam. 1988. Effect of nitrogen and phosphorus on the production potential of pearl millet - cowpea or green gram intercropping system under rain fed condition. Soils and Fertilizers. Vol. 51 No. 1.

Lathwell, D.J. 1979. Crops response to liming of Ultisols and oxisols. New York College of Agriculture and life Science, Cornell International Agriculture Bulletin 35: 15-16.

Ofori, C.S. 1971. Effect of lime application on maize yield on a forest ochrosol. Soil Research Institute Annual Report. Soil Research Institute, Kumasi.

Patrie, S.E. and T.C. Jackson. 1984. Effect of fertilization on soil pH and manganese concentration. Soil Sc. Soc. Am. J. 48: 315-318.

Rani, P. S. Baskaran, P. Duraisamy and S. Chellamuthu. 1989. Soil test crop response studies with organic and inorganic nutrients on finger millet. Soil and Fertilizers. Vol. 52 No. 12.

Reddy, M.G.R.K., S.R. Reddy, P.R. Reddy, K. Subrahmanyam and M.V.R. Subrahmanyam. 1987. Effect of nitrogen and phosphorus uptake on finger millet. Soil and fertilizer. Vol. 50 No. 10.

S.R.I. 1970. Varietal response of guinea corn to different forms of nitrogen fertilizers. Soils Research Annual Report. Soil Research Institute, Kumasi.

S.R.I. 1978. Nitrogen fertilization and water management of rice at Vea. Soil Research Institute, Kumasi.

DISCUSSION

D.K. ACQUAYE

As you rightly pointed out, there should be no response to lime unless the pH is below 5.5. But the soils ranged between pH 4.6 and 6.8. It therefore appears there will be difficulty in interpreting the results. Please comment.

R.N. ISSAKA

The pH of the bulk sample was certainly below 5. The pH of the individual plots after the plots were demarcated varied widely between 4.5 and 6.5 with over 90% below 5.5. As pointed out it would have been necessary removing the few plots that had high initial soil pH. This will be considered in subsequent experiments.

T. DEL GIUDICE

In your conclusion you said that liming is necessary in improving the pH of the soil. My question is whether the target pH value should not be related to the soil type (sandy, loamy or clay soils).

R.N. ISSAKA

Certainly the target pH will vary depending on the soil type. The soil in which this experiment was conducted is sandy-loam and the conclusion so mentioned was in this respect.

A. RABI

How can one determine the pH of soil before planting without visiting the laboratories?

R.N. ISSAKA

Kits are available for pH testing on the field. It is certainly impossible to know the pH of a soil by just looking at it.

S. OHENE DEPAAH

Your table of means doesn't specify whether there are any significant interactions or not . If not why presenting means of interactions?

R.N. ISSAKA

Interaction was not significant. The means were presented to emphasise a point; that liming is not all that necessary for all types of fertilizers and that it is most necessary under critical soil pH conditions.

THE NEEM TREE (AZADIRACHTA INDICA, A. JUSS): POTENTIAL USES IN CROP PROTECTION IN GHANA

Paul B. Tanzubil

(Nyankpala Agricultural Experiment Station)

Introduction

Over a third of the global food production is lost annually to pests and diseases (McEwan, 1978). Highest losses of this nature occur usually in the developing countries of Asia and Africa, where yield losses can be as high as 42% of the total agricultural production (FAO, 1980).

To reverse this trend, these countries have, for the past decade or more, relied very heavily on synthetic pesticides produced by the developed countries. There have thus been increases in the quantity and diversity of pesticides imported into the third world over the years, yet pest-induced yield losses have seldom changed. Apart from the high costs and subsequent inavailability of these pesticides and their application equipment, the chemical control technology has other attendant problems. The use of synthetic pesticides in rural communities has often created health hazards to man and his livestock. The environmental pollution aspects are also worth emphasising, especially in these areas where facilities for residue monitoring and management are absent and effective health care may be a dream. There are also technical problems associated with the wanton use of pesticides such as pest resurgence, secondary pest outbreak and the escalation of pesticide resistance in target organisms.

This awareness has created a world-wide interest in the re-evaluation and use of traditional pest control materials, especially those of botanical origin. The Neem tree (Azadirachta indica, A. Juss) which grows widely in the tropics, has shown promise as a good source of pest control materials. This paper assesses the potential for using derivatives of this tree for crop protection in Ghana, with emphasis on insect pest control.

The neem tree - historical uses

The Neem tree originated from India but today is found in South-east Asia, Africa and the tropical regions of America (Jotwuni and Srivastava, 1984). It has been an economically important tree species for many decades, its products being used in oral hygiene preparations, traditional medicine and soap manufacture. Tannins from the bark of this tree are widely used in the leather industry, while its oil serves as fuel power for rural folk in many Asian countries.

In agriculture, Neem has been a source of fertilizer in the form of oil seed cake, twigs and ash. The efficiency of fertilizer nitrogen in the tropics is reckoned to be low, usually between 30 - 40% (De Datta, 1978). Neem seeds contain fatty acids which are capable of inhibiting the nitrifying bacteria that are largely responsible for this, thus increasing

the efficiency of applied nitrogen fertilizers (Ketkar, 1976). Thus in field trials, Bains et al (1971) obtained a 22% yield increase by blending urea with Neem cake and this incidentally, was superior to sulfur-coated urea. Neem leaves constitute useful fodder for livestock, especially during the long dry season in Africa. Apart from the direct feeding value, these are reputed to have therapeutic effects against intestinal worms in these animals (Radwanski, 1977). The most important use in agriculture however is perhaps that relating to crop protection and this aspect is considered in some detail in this paper.

The Neem tree: Possible uses in crop protection

(1) Nematicidal properties

There have been various reports on the nematicidal action of extracts from Neem which could be exploited for control of plant-parasitic nematodes. Direct toxic action of Neem leaf and seed extracts have been reported variously against Pratylenchus, Meloidogyne, Rotylenchulus and Rhadopholus spp. among others (Olufunke and Afolami, 1976; Gill and Lewis, 1977). These are general important plant parasites that can sometimes prevent profitable cultivation of crops on fields they infest, especially in vegetable gardens or at irrigation sites. The above findings indicate therefore that soil-applied Neem products, apart from enhancing soil productivity, could or should reduce the incidence of nematodes. This aspect deserves more research attention, as it presents interesting implications for practical agriculture.

(II) Effects on pathogenic organisms

Adverse effects of Neem on pathogenic organisms of crops as well as animals have been documented. Anti-viral action has, for instance, been recorded against such disease causal agents like vaccinal virus, fool pox virus and potato virus (Singh 1971, Rai and Sethi, 1972). Similarly, Khan et al (1974) recorded effective control of various plant pathogenic fungi using Neem extracts. The use of Neem soil drenches against slugs and snail pests has equally been documented. Although still far-fetched, the above account shows that it might be possible in the future to think of employing Neem products for control of crop and animal deseases.

Insect control properties of the neem tree

The insect control properties of Neem may include the following:

(a) Antifeedant and/or repellent action

Of the currently known insecticidal properties of extracts from the Neem tree, the oldest perhaps have been its repellent and antifeedant action. Bhatia and Sikka (1957) reported feeding inhibition and repellent effects of Neem against the desert locust (Schistocerca gregaria) and since then, there have been

similar reports for over 30 species of insects that are of economic importance as crop pests (Ahmed et al., 1984). The antifeedant effects are known to result from sensory detection and avoidance by the insect upon contacting and biting the treated surface (Simmonds and Blaney, 1984). It has been shown also that a second type of antifeedant action can be observed following treatment of the insect rather than its food with Neem. Thus larvae of the African armyworm contaminated with Neem are unable to feed effectively on untreated host plant foliage (Tanzubil and McCaffery, 1989). This type of antifeedant action does not appear to be due to taste receptor sensitivity as stated above, but probably results from interferences of the Neem products with centres in the insect that control or regulate feeding, food passage and metabolism (Tanzubil, 1989).

Additionally, insects treated with Neem, or those that feed on Neem-treated foliage suffer other nutritional defects; they show reduced food conversion and utilisation efficiencies hence impaired growth and development.

Crops sprayed with Neem extracts can thus be instantly protected from insect damage through the primary, gustatory repellent effects. Secondly, insects that pick up residue during foraging could suffer nutritionally, even if they moved into unsprayed fields.

(b) Growth disruptive action

One other important insect control property of Neem is its growth disruptive action. Neem derivatives applied to juvenile insects or their food may induce precocious metamorphosis, supernumerary development, absence of moults or various forms of moulting abberation (see Schmutterer et al, 1981; Schmutterer and Ascher, 1984). The effect here would be a failure of the affected insect to develop into normal adults.

It is believed that these disruptions are consequences of interference of Neem with endocrine events in the insect, especially the synthesis, titre and activity of important hormones that regulate growth and development, particularly ecdysone, juvenile hormone and prothoracicotropic hormone (ptth) (Fagoone and Lauge, 1981; Schmutterer, 1988).

Thus apart from the antifeedant effects described earlier, Neem derivatives applied to many insects or their food would also prevent their development into viable adults. The overall effect could be a reduction in population build-ups and hence, reduction in the pest incidence and crop damage.

(c) Anti-reproductive effects

Neem products have also exhibited anti-reproductive action in target insects. These can include delayed reproductive maturation, oviposition deterrence and reduced fecundity or outright sterilisation. Using the African armyworm (Spodoptera exempta), Tanzubil (1989) showed that reduced fecundity in Neem-treated moths was due primarily to interference of Neem with oogenesis, particularly vitellogenin synthesis and its uptake by developing oocytes.

Although eggs laid by such insects may hatch normally, they give rise mainly to non-viable offspring, less than 40% of which survive to the 4th instar. Also, treated eggs hatch normally but produce non-viable progeny. Similar antireproductive effects of Neem derivatives have been reported in many insects (Schmutterer and Ascher, 1984).

These clearly show that in practice, Neem derivatives could be useful in regulating insect populations, whether they are applied topically on to the insect, its food, or even its eggs laid on crop foliage. Since the modern concept of pest control emphasises the establishment of some kind of pest residue to sustain natural enemies, these materials which do not tend to annihilate the pest, would seem ideal.

Desirable attributes of neem as a source of pest control materials for the Ghanaian farmer

Available evidence so far points a great potential for developing Neem-based pest management systems in Ghana and other developing countries. Apart from the encouraging results obtained with its products at Nyankpala (Tanzubil, 1987 and 1990), the following attributes make Neem a really promising tree for crop protection in Ghana:

(i) Safety and selectivity

Neem derivatives are relatively safe to non-target organisms and also exhibit some degree of selective action. This property makes good sense as it enhances the chances of applying Neem with fewer environmental side effects. Concentrations of up to 8500 mg/kg body weight of Neem extract proved non-toxic to rats when applied orally (Schmutterer, 1984). Neem is also reputed to be relatively safe to predators and parasites as well as pollinators (Saxena et al., 1981; Srivatava and Parma, 1985; Schmutterer and Holst, 1987). This enhances their potential as practical pest control agents, since their use could help augment natural enemy populations and thus enhance natural control.

The safety aspect makes Neem particularly useful for stored product protection, especially as it has been shown to be effective against a variety of stored product pests (Jotwani and Sircar, 1965; Ivbijaro, 1983; Tanzubil, 1987).

(ii) Ease of cultivation and utilisation

The Neem tree is hardy and easy to grow, requiring little attention from the farmer. The active principles are also obtainable via simple extraction procedures, and applicable in different forms. For instance, simple aqueous seed extracts tested at Nyankpala significantly reduced thrips (Megalurothrips sjostedti) incidence in cowpeas while Neem seed dust, obtained by milling dry kernels, afforded ample protection to stored cowpeas for over 4 months under artificial infestation with the cowpea weevil (Callosobruchus maculatus) (Tanzubil, 1990). These products are certainly easy to prepare and use at the farm level by any peasant farmer and need to be exploited.

(iii) Availability and economy

Neem trees grow widely in Ghana and can be established easily at most locations. This means that development of Neem technology could reduce the cost of crop protection, especially in rural communities where farmers may want to use pesticides but lack the necessary funds to purchase them. Saxena (1982) estimates that each Neem tree can produce between 30 to 50 kg seed annually, enough to protect one hectare of rice against insect damage. The several other uses of the tree make it really important for Ghanaian agriculture from the economic and ecological points of view.

(iv) Systemic properties

Systemic action of Neem has been reported by Gill (1972), Gill and Lewis (1977) and Saxena (1982) among others. This property means added selectivity, but more important perhaps, improvement in the residual life of Neem derivatives on treated foliage. This property also enables new growth as well as parts of the plant not covered during sprays to be protected from pest damage. This implies also that Neem derivatives can be used to control not just chewing and biting insects, but also sucking ones.

(v) Compatibility with other control options

One of the promising areas where Neem could be useful is in the field of integrated pest management (IPM). Its relative safety to predators and parasites should make it compatible with biological control. Synergistic action with some insecticides, notably the pyrethrins (Ahmed et al., 1984; Hellpap, 1984) also suggest its favourable use with conventional insecticides.

In fact, work at Nyankpala (Tanzubil, 1990) showed that treating cowpeas with Neem seed extracts resulted in increased exposure of Maruca testulalis larvae. Apart from enhancing biocontrol, this could increase the window of activity and hence efficacy of insecticides applied to control this insect.

(vi) Diverse mode of action

Since Neem can exhibit a range of effects on an insect, it is unlikely that development of resistance to it by insects can occur, at least not as rapidly as it does with synthetic insecticides. Vallinger (1987) found no sign of resistance in Plutella xylostella moths treated with Neem seed kernel extract for 42 generations while deltamethrin treated lines developed resistance up to 35 times that of controls.

References

Ahmed S., M. Grainge, J. W. Hylin, W. C. Mitchel & J. A. Litbinger (1984). Some promising plant species for use as pest control agents under traditional farming systems: In: Proceedings of 2nd International Neem Conf. (Schmutterer & Ascher eds.): 565 - 587.

Bains S.S., Prasad R. & Bhatia P.C. (1971). Use of indigenous materials to enhance the efficiency of fertilizer nitrogen in rice. Fertilizer News, 16 (3): 30 - 32.

Bhatia D.R. & Sikka (1957). Some striking cases of food preference by the desert locust, (Schistocerca gregaria): Indian J. Entomol., 18: 205 - 211.

De Datta S. K. (1978). Fertilizer management for efficient use in wetland rice soils. IRRI, Soils and Rice: 671 - 701.

FAO (1980). Food Production Year Book FAO, Vol. 4, Rome Italy, 1980.

Gill J.S. & C.T. Lewis (1977). Systemic action of an insect feeding deterrent. Nature, 232: 402 - 403.

Hellpap C. (1984). Effects of Neem Kernel extract on the tall armyworm (Spodoptera frugiperda): In: 2nd Int. Neem Conf. 353 -363.

Gill J.S. (1972). Studies on insect feeding deterrents with special reference to fruit extracts from the Neem tree. Ph.D thesis Univ. of London, U.K.

Ivbijaro M.F. (1983). Toxicity of Neem seeds to Sitophilus in stored maize. Protection Ecol., 5: 353 - 357.

Jotwani M.G. & K.P. Srivastava (1984). A review of Neem research in India in relation to insects. In: Proc. 2nd Int. Neem Conf.: 43 - 56.

Ketkar C.M. (1984). Crop experiments to increase the efficiency of urea fertilizer nitrogen by use of Neem products. In: Proc. 2nd Int. Neem Conf.: 507 - 518.

McEwan F. (1978). Food Production - The challenge of pesticides. Bioscience, 28: 773.

Olufunke A. & E. Afolami (1976). Effect of Neem leaf extract on populations of Pratylenchus brachyrius and on the growth and yield of maize. Nematologica, 22: 125 -132.

Radwanski A. (1977). Neem tree. World Crops & Livestock, 29:61 - 66.

Saxena R.L. (1982). Note on the use of Neem kernel for protection of dewgram against Amsacta morrei. Indian J. Agric. Sci., 1: 51 - 52.

Schmutterer H. (1988). Potential of azadirachtin containing pesticides for integrated pest control in developing countries. J. Insect Physoil., 34 (7): 713 -179.

Schmutterer H. & K.R.S. Ascher (1984). eds): Natural pesticides from the Neem tree and other tropical plants. Proceedings of the 2nd Int. Neem Conf. (Rareischholzhausen, 1983): 587 pp.

Schmutterer H., K.R.S. Ascher & H. Rembold (1981). eds: Proc. of the 1st Int. Neem Conf. (Rottach- Egern, 1980): 297 pp.

Simmonds M.S. & W.M. Blaney (1984). Some neurophysiological effects of azadirachtin on Lepidopterous larvae and their feeding response. In: Proc. 2nd Int. Neem Conf: 163 - 180

Tanzubil P.B. (1987): The use of Neem products in controlling the cowpea weevil, Callosobruchus maculatus In: Proc. 3rd Int. Neem Conf. Nairobi (Schmuttere & Ascher eds): 517 - 523.

Tanzubil P.B. (1989): Effects of Neem (Azadirachta indica) on the African armyworm and their implications for field control. M. Phil thesis, Univ. of Reading, U.K.

Tanzubil P.B. (1990): The control of insect pests of cowpeas with Neem in Northern Ghana. Tropical Pest Management (in press).

Tanzubil P.B. and A.R. McCaffrey (1989): Effects of Neem on feeding and reproduction in the African armyworm: In: Proc. of DLG Symposium on IPM in tropical and sub-tropical countries Bad Durkheim, Feb. 1989, FRG) (in press)

Vollinger M. (1987): The possible development of resistance against Need seed kernel extract and deltamethrin in Plutella xylostella. In: Proc. 3rd Int. Neem Conf.: 543 -554.

Discussion

J. GYESEY

Which one is effective using neem tree with ground pepper or using it alone when diluted with water?

P.B. TANZUBIL

The addition of pepper may enhance knockdown as this is supposedly toxic to insects. It therefore depends on the situation but I personally would not go in for such cocktails.

A. RABI

How effective is neem dust or oil in the control of rodents in maize storage?

P.B. TANZUBIL

There is evidence that up to 8500 mg/kg body weight neem extract is non-toxic to rats. I therefore doubt one can control rodent pests with neem.

F.A.K. MENSAH

How is the N.S.O extracted? (2) what are the chemical compositions of the neem? (3) what have you done with the neem leave liquid?

P.B. TANZUBIL

(1) There are 2 extraction procedures. Cold and hot press. The hot press is similar to groundnut oil extraction while the cold press involves kneading the neem seed powder continuously. Details can be supplied later.

(2) There are many active principles in neem. The most potent is AZADIRACHTIN. Other effective ones are SALANIN and MELIANTRIOL.

(3) The leaf extract proved effective against thrips but not so effective against cowpea bruchids. The leaf is known to contain lower levels of azadirachtin than the seed hence its use has been de-emphasised in our work.

G.K. SOWLEY

The neem tree parts are bitter and therefore will confer this bitterness to treated seed. How easily can this bitterness be removed from the consumable seed?

P.B. TANZUBIL

It is true. Neem seed oil particularly used at levels about 4 ml/kg seed (cowpea) may impart bitterness to the seed and hence is recommended for treating planting material . Neem seed powder however seldom creates this problem. Additionally, low doses of both products can be used together with a longer post-treatment consumption period.

E.E. YELEWERE

The use of neem as an antihelmintic in livestock?

P.B. TANZUBIL

Our mandate does not cover animal research. The feeding studies referred to were mainly based on oil seed cake which is obtained after oil extraction from neem seed. Details can be supplied on request later.

H. RUDAT

In Tchad neem leaves are widely used in the farm households to protect against insect infestation of seeds and cloths. What can we do on our local level here in Ghana? Using extract or leaves or seeds?

P.B. TANZUBIL

Our work has shown that both leaf and seed extracts have a potential. For practical purposes however, I would recommend the seed extracts because:

(1) Dry seed contains oil which is very effective against stored product pests and also field pests

(2) The seed contains higher amounts of azadiracthtin, the principal active ingredient of neem.

SESSION 4

CHAIRMAN: MR. R.D. ASIAMAH, DIRECTOR, SRI

ECONOMIC ANALYSIS OF YAM PRODUCTION IN NORTHERN GHANA

A. S. Langyintuo

(Nyankpala Agricultural Experiment Station)

1 Introduction

Yam is a very important crop in Northern Ghana. Its role in the dietary needs of the people cannot be overemphasised. Peeled yam may be sliced and fried in oil or cooked and served with stew. It could also be eaten as fufu after pounding the boiled slices in a wooden mortar to produce a glutinous dough. Small tubers roasted commonly serve as a meal during field work. Slices could be sun dried and later pounded or milled into flour to be used in the preparation of a meal.

Yam finds a ready market in the Bimbilla, Salaga, Sawla, Wa and Tumu Districts. It is an important cash crop in these areas and in fact almost all the farm family cash income is from the sale of the crop. In the Tamale area where it is heavily intercropped with cereals and legumes, the yam based mixture gives the highest gross revenue per unit area than other mixtures (RUNGE-METZGER, 1987).

Between 1960 and 1977 when there was a gradual increase in yam production in Africa (NGAMBEKI, 1981), Ghana was one of the major yam exporting countries. An average of 1200 tons per annum was exported for the period 1960-65, which rose to 3100 tons per annum (with a small percentage of cocoyam) between 1966-70 (KAY, 1983). Production in Ghana began to fluctuate from 1977-80, and a gradual decline afterwards (Table 1).

The Northern and Upper Regions also experienced fluctuation in both yield and production. Production in the Upper East and West Regions (U/Rs) relative to the Northern Region (N/R) was negligible (Table 2).

TABLE 1: TREND IN THE PRODUCTION OF ROOTS AND TUBERS IN GHANA, 1977-83 (1000 T)

	Year						
Crop	1977	1978	1979	1980	1981	1982	1983
Yam	497.1	517.1	550.4	523.1	462.8	374.1	354.3
Cassava	2119.0	2334.3	2319.9	2896.3	2720.6	1985.5	1375.2
Cocoyam	632.6	680.7	698.5	848.3	972.0	756.3	613.2

Source: GIRI (1986)

TABLE 2: PERFORMANCE OF THE YAM INDUSTRY BY REGIONS, GHANA, 1977-83

Year	Area (000 ha)		Production (000 t)		Yield (kg/ha)	
	N/R+	U/Rs++	N/R	U/Rs	N/R	U/Rs
1977	26.3	4.2	105.6	25.9	4015	6167
1978	43.9	5.0	175.9	31.6	4007	6200
1979	57.6	7.8	230.8	48.3	4007	6192
1980	40.1	6.1	160.6	38.0	4005	6230
1981	47.5	7.1	190.2	48.3	4004	6192
1982	43.4	6.5	156.6	36.0	3608	5538
1983	41.2	6.6	148.6	36.8	3607	5576

\+ = Northern Region
++ = Upper East and West Regions
Source: GIRI (1986)

However, yields in the Upper Regions were higher than those in the Northern Region.

The Policy Planning Monitoring and Evaluation Division (PPMED) of the ministry of Agriculture conducted a survey on food crop production in 1987. In the survey year about 863,000 tons of yam was produced, which was 12.65% lower than the 1986 production of 988,000 tons. Domestic demand consequently outweighed production by 13,000 tons (Fig. 1). Northern Region produced a surplus of 104,100 tons (PPMED, 1987), nevertheless, a decline was observed.

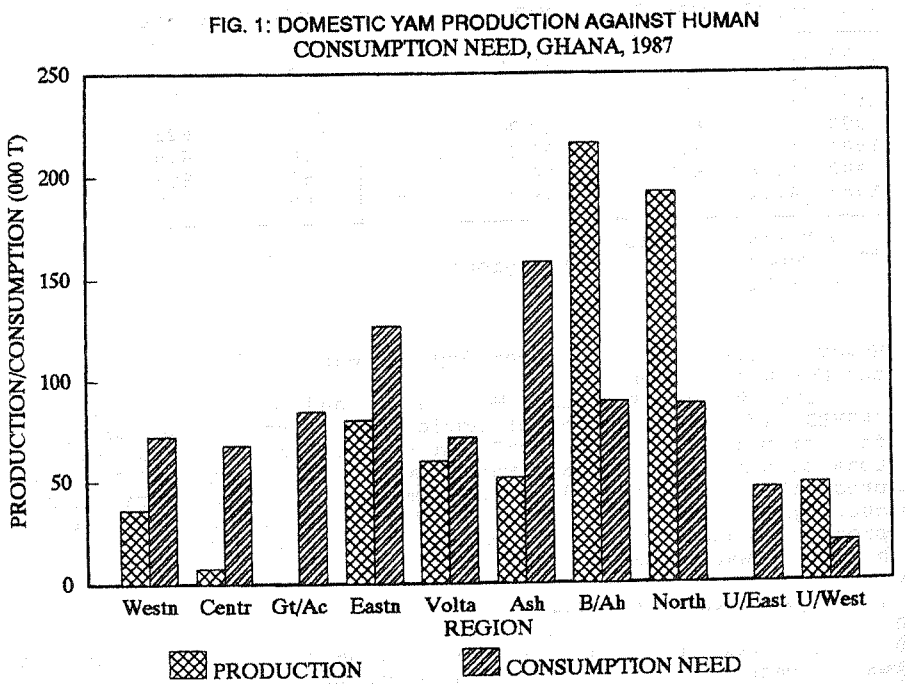
1.2 Objectives of the Study

In view of the progressive decline in yam production, it was necessary to study it's production and to identify the potential constraints. The description of yam production in Northern Ghana, it's relevance in the farming system of the area, and avenues for the development of yam production were sought in this study.

1.2 Methodological framework

Two villages near Tamale, Wantugu and Cheshegu, were selected for a case study. Twenty and nineteen farmers were respectively selected from these villages. Data were collected from March 1988 through January 1989. Two types of questionnaires were used; a full-season questionnaire on agronomic, input, output and labour records, and a one-shot questionnaire on general aspects of yam production. Descriptive statistics, correlation, regression and gross margin analysis were used in the analysis of the collected data.

Fig. 1:



2 Production technology

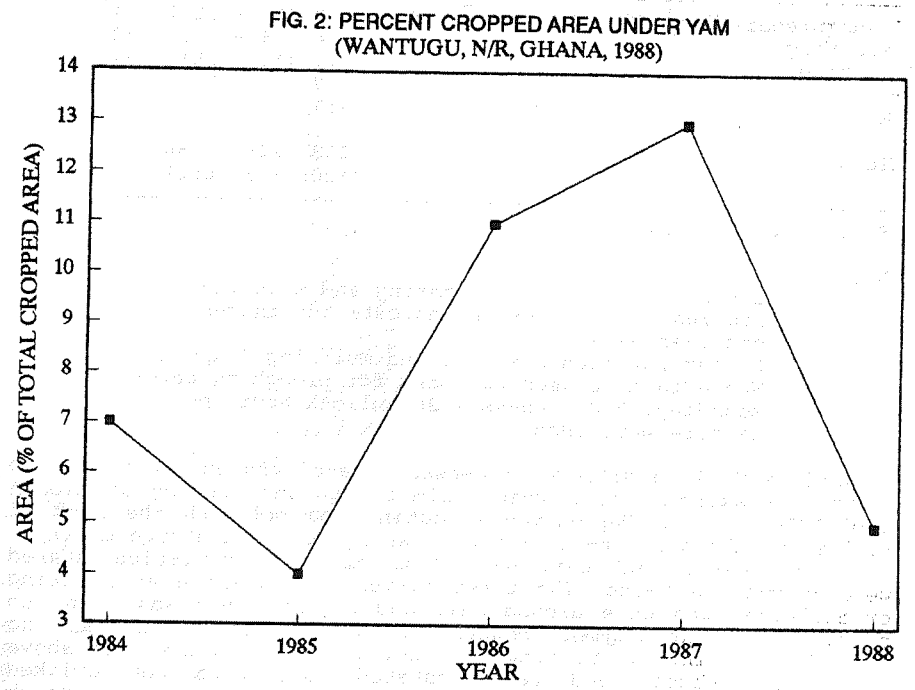
2.1 Husbandry practices

Soil preparation was accomplished around March and April 1988. This operation was preferably done in October and November, with the residual rains of the previous season, for a possible early planting and consequently high yields (KAY, 1983). Labour out-migration to the Brong-Ahafo and the Eastern Regions in search of off-farm employment nullified this objective. Seed beds were made as mounds of between 0.39 and 0.49 m high, spaced at 1.3 x 1.2 m apart giving rise to an average of 6400 mounds/ha.

Alongside the mounding was planting and capping (or mulching) with grass or leaves of trees and shrubs. Seed yams were planted to the depth of between 5 - 15 cm.

Fields were weeded about four times from June through September with a conscious effort to keep fields free from

Fig 2



weeds. The uneven sprouting of the seed yams resulted in the increase in the number of weedings which otherwise would have been two.

After a month of planting when sprouting begun, staking was initiated using stakes obtained from shea and dawadawa trees. The average length of the staking material was about 0.9 m against the economical length of between 1.5 to 2 m (PURSEGLOVE, 1972; IITA, 1983; and LYONGA and AMBE, 1983). Efforts were made to stake the early and early-to-medium maturing yam varieties (Kpuno, Labarko, and Chinchito). Though these made up about 70% of the yams planted, 43.5% were staked. This was due to the unavailability of stakes as the vegetation was sparse. It was, however, thought that staking of the late maturing varieties (Kpirinsi, Ziglangbo, Nyuwagu, Fula, Kagbaransi, and Kpirinkpila) was uneconomical as there was no

TABLE 3: LABOUR REQUIREMENT (MANDAYS PER HECTARE) FOR YAM PRODUCTION IN THE TAMALE AREA, 1988

Operation	Village: Wantugu	(CV%)	Village: Cheshegu	(CV%)
Land preparation[1]	88 (64 - 104)[2]	14	102 (80 - 125)	14
Planting[3]	22 (15 - 30)	24	24 (14 - 35)	33
Staking	21 (15 - 26)	17	19 (14 - 25)	22
Weeding	93 (75 - 105)	11	97 (80 - 124)	13
Harvesting	13 (8 - 20)	30	17 (13 - 22)	20
Total	237 (205 - 256)	7	258 (225 - 286) (208 + 36 bhr)[4]	9

Source: Field survey

Notes:
1) Labour for both land clearing and mounding.
2) Figures in parentheses indicate the ranges of the observed data.
3) Labour for both planting and mulching (capping).
4) Where farmers used bullocks for ploughing before mounding, 208 mandays + 36 bullock hours per hectare were used.

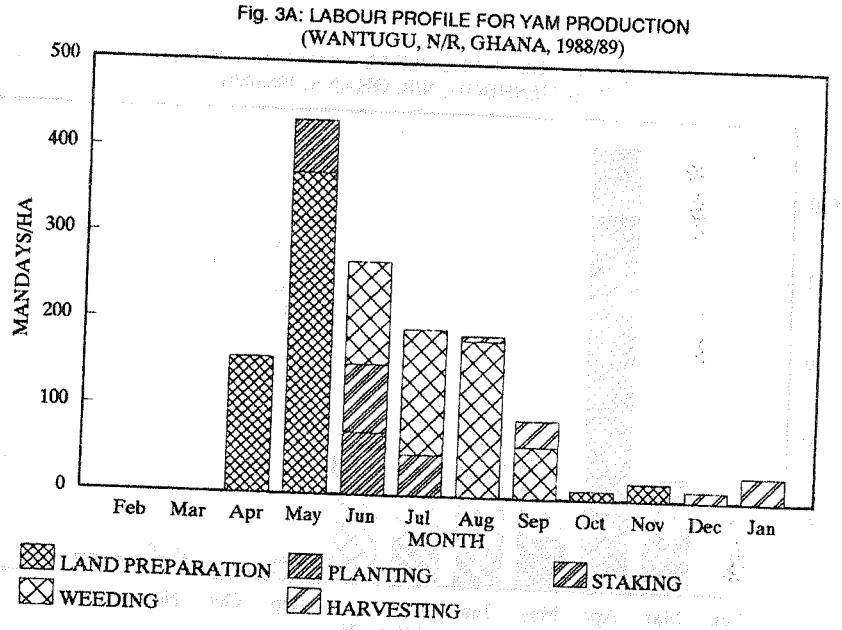
significant yield difference between staked and unstaked ones to justify staking them, a reason similar to the finding of LYONGA and AMBE (1983). The uneven sprouting coupled with the lack of stakes resulted in the operation lasting for about three months.

The early and early-to-medium maturing varieties staked were harvested twice. The first harvest, also known as pricking or milking, was done around July and August. This was meant to provide food to augment cowpeas to bridge the hunger gap, to provide cash income to finance other farm operations, and above all, to produce seed yam. Unstaked yams were not pricked because, at the time of pricking tubers were not big enough to provide food or
cash. Also tuber regrowth was hampered. From November to January when the second harvest was done for all yams
planted, staked yams were harvested first to reduce the incidence of rot. Devoid of dry vines on the mounds unlike the unstaked ones to provide a cooling effect, staked yams rot from the heat of the sun.

2.2 Post harvest handling

Yam was produced mainly for home consumption. Between 34 and 44% was consumed. As farmers were sales oriented, 4 to 13% of the produce was sold in either the Tamale urban market or in the village. In fact, nearly all yams sold

Fig. 3a

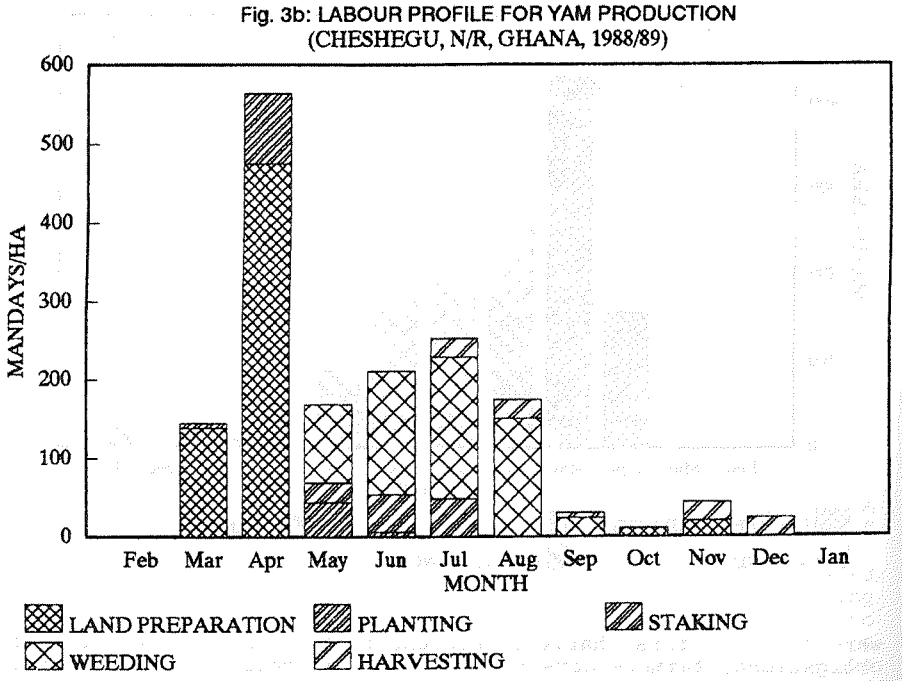


were from the first harvest. For the fulfillment of their social obligations, farmers gave out 2 to 4 % of their produce as gift. More than three quarters of this quantity went to
chiefs and parent in-laws. Between 21 to 30 % was meant for seed and the rest for contingency. To store, yams were heaped in a shade and covered with yam vines or put in a hut made of grass.

3 Economics of production

Land in the area was communally owned and farmers thus had usufructuary rights to its use. No alleviation of it was allowed and therefore attracted no rent. Yam was grown as the first crop in the crop rotation cycle by all farm families. In the choice of a field for yam cultivation,

Fig. 3b



longest fallowed fields were of priority. The estimated R-value (R = number of cropped years/number of cropped years + number of fallow years), which gives an indication of the intensity of land use (RUTHENBERG, 1980), was 0.71. It meant that 71 % of the total arable land was cultivated annually. In the absence of fallowed fields, fields on which yam was not cultivated the previous season was a substitute. Averagely, 0.25 ha, about 5% of the total cropped area, was under yam (Fig. 2). A severe incidence of seed yam rot in storage contributed to the reduced area under yam*.

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* Source: NAES Economics Section Village Surveys (1984 - 1988)

The low level of cash resources of the farmers coupled with the lack of a class of landless labourers imposed a restriction on the hiring of labour. As a result farmers depended on family labour for the various field operations. Communal labour which is generally regarded as a form of family labour for its reciprocal nature (SEINI, 1985), was also a source of labour. As a labour intensive crop mixture, the yam based mixture attracted a total labour input of between 237 to 258 mandays/ha. Land preparation and weeding were the most labour demanding operations (Table 3 and Fig. 3a and b). The farmer saved 50 mandays when bullocks were used for partial land preparation (land clearing only).

Seed yams of about 1000 kg planted to a hectare were obtained from the previous seasons harvest. Where a farmer had not sufficient seed yams, he got some from a neighbour free of charge or for payment in cash or in kind. Kind payment was in the form of supply of an agreed amount of labour by creditor or a similar quantity of seed yam payable at the end of the season.

Mulch and stakes were obtained free of charge from the nearby bushes employing family labour.

TABLE 4: STAKING EFFECT ON YAM YIELDS IN THE TAMALE AREA, 1988

Variety	Staked and milked (kg)	Staked and not milked (kg)	Un-staked and milked (kg)	Un-staked and not milked (kg)
Kpuno	2.10	1.58	0.69	1.18
Larbako	1.88	1.04	0.61	1.01
Chinchito	1.86	1.41	0.56	0.87
Kpirinsi	-	-	-	1.42
Ziglangbo	-	-	-	0.76
Nyuwagu	-	-	-	1.00
Others*	-	-	-	1.12

Source: Field data

Note: * Includes fula, kagbaransi, and kpirinpkila.

TABLE 5: GROSS MARGIN ANALYSIS OF THE YAM BASED ENTERPRISE IN THE TAMALE AREA, 1988[1]

		Wantugu	CV%	Cheshegu	CV%
Output (minus seed):					
Yam	kg/ha	2300	46	4200*	25
Price of yam	¢/kg	30	-	30	-
Revenue (yam)	¢/ha	69000	34	126000	30
Intercrops	kg/ha	292*	67	190	115
Average price	¢/ha	73	-	84	-
Revenue (int.crops)	¢/ha	21300	65	16200**	126
Total Revenue	¢/ha	90300	50	142200**	70
Labour input	Mandays/ha	237	7	258	9
Revenue per manday		381	49	551*	46
Mandays per ton of yam		71	59	48	41

Source: Field data

Notes: Error levels at which the two means differed were defined as: * 5% and ** 1%

1. Yields of cassava, calabash and okra were eliminated from the analysis. Cost of tools was also excluded as it was insignificant. Compared with the daily wage of a labourer of ¢170.00, the yam farmer was better paid.

Average yields ranged between 3.3 to 5.3 t/ha. Early planting increased yam yield. Farmers who planted in April harvested 5.3 t/ha while those who planted in May, 3.3 t/ha.

Staked yams yielded higher than unstaked ones (Table 4). Pricking had no effect on total yield of staked yam. On the other hand if yams were not staked, pricked yams yielded significantly lower than those not pricked, thus rationalising farmers practice of pricking only staked yams.

With the basic assumption that a similar quantity of output would be reserved as seed for the next season, estimation of the gross margin was based on the total output less 1000 kg. The total gross margin of between ¢90300.00 and ¢142200.00 a hectare gave a labour productivity of between ¢381.00 and ¢551.00 (Table 5).

4 Recommendations

For the development of yam production the following recommendations are given:

1. The existing yam varieties in the area should be screened for tolerance to pests and diseases especially those caused by fungi, and high yield potential with little or no staking.

2. For good quality seed yam another method rather than the traditional one would be appropriate. The minisett technology could be a solution. Identification of locally procured sprouting materials would be beneficial to the farmers.

3. The appropriate planting dates of available varieties, the right crop combination in intercrops and the optimum plant populations of both yams and intercrops should be established.

4. In the long run genotypes of yam with morphological and physiological characteristics which do not require staking would be appreciated.

5. Reduction of labour time and particularly lowering the labour peak is possible with mechanisation.

Though this recommendation could be far fetched, the use of bullocks for partial land preparation could help a little.

References

GIRI, R., Estimates of Area and Productivity of Principal Crops in Ghana, 1977-83, Accra, Economic Research and Planning Service of the Ministry of Agriculture, Ghana and the UNDP/FAO Improvement of Agricultural Statistics Project GHA/84/003

IITA 1983; IITA Research Highlights, IITA, Ibadan, Nigeria

KAY, D. E. (Mrs), Root Crops; Crops and Products Digest 2. The Tropical Products Institute, Foreign and Commonwealth Office (Overseas Development Administration), 1973. Pages 190 - 200

LYONGA, S. N. and AMBE, J. T., The effects of staking on tuber yield of three cultivars of trifoliate yam. In Proceedings of the 2nd Triennial Symposium for Tropical Root Crops - Africa Branch; Douala, Cameroun, 14 - 19 August, 1983. Pages 138-139

NGAMBEKI, D. S., Trends in Production of Root Crops in Africa. Agricultural Economics Information Bulletin, No. 3; IITA, Ibadan, June 1981. Pages 1 - 5

NWANKITI, A. O. and AHIARA, I. U., Effects of time of Staking on the Development of Anthracnose Disease of Water Yam. In Proceedings of the 2nd Triennial Symposium for Tropical Root Crops - Africa Branch; Douala, Cameroun, 14 - 19 August, 1983. Page 140.

NAES (Nyankpala Agricultural Experiment Station), Economics Section, Village Level Surveys, 1984-88

POLICY PLANNING MONITORING AND EVALUATION DIVISION (PPMED), Performance of The Agricultural Sector. PPMED, Ministry of Agriculture, Accra, Ghana, 1987 Pages 30 - 36

PURSEGLOVE, J. W., Tropical Crops, Monocotyledons. Longman Group Limited, 1981. 8 pages.

RUNGE-METZGER, A., Variability in Agronomic Practices and Allocative Efficiency Among Farm Households in Northern Ghana, A Case Study in On-Farm Research. CRI/GTZ, 1987

RUTHENBERG, H., Farming System in The Tropics. Clarendon Press, Oxford, 3rd Edition, 1980. Pages 70 - 109

Discussion

O. ABDEL-RAHMAN

Why were Cheshegu and Wantugu villages chosen for the survey instead of Bimbilla. Kpandai, Salaga which are noted for yam production in the region?

A. LANGYINTUO

Wantugu and Cheshegu were the survey villages for the NAES Economics section as such the device of these villages enabled a dual purpose of conducting the survey as well as supervising village level surveys conducted by the section. If logistics permit surveys would be carried out in the areas indicated.

A. RUNGE-METZGE

What were the reasons for low yam yields in the two villages in 1989?

A. LANGYINTUO

Mainly the intensity and duration of rains during the season was a contributory factor to the reduced yields.

A.B. SALIFU

Can you expand on what differences have brought about a result of 1 month lapse in planting between the two areas of your study?

A. LANGYINTUO

Apart from other agronomic factors that could not be identified, the positive effect of early planting on yam yield contributed emersely to the differences.

P. K. DROBOH-AMEYAW

(1) Has the height of the stakes any effect on yam yield? (2) Which is more recommended for maximum yield, individual mound staking or community mound staking that is, 1 stake for 2, 3 or 4 mounds or (3) Does the size of the setts influence the yield of the tuber.

A. LANGYINTUO

(1) The height of a stake has a positive effect on yields. Between 1.5 and 2 m is the economical stake height beyond which it is not economical as yield increase is not significant to justify their use.

(2) The more plant leaves are exposed to insolation the more yields are expected. Folowing this it is apparent that individual staking is most appropriate. However, the use of a stake for at most 3 mounds could compete favourably.

(3) There is increase in yield with sett weight up to 1.5 kg.

NAES RESEARCH EXTENSION LINKAGES

Jens von Bargen

(Nyankpala Agricultural Experiment Station)

Introduction

In May 1989 a workshop on the linkages between research and extension was held in Accra. People involved in policy making, in research, in the generation of technology and in dissemination as well as farmers representatives assembled there to discuss the present state of affairs.
The issue of the relationship and linkages between the two sectors has always been the reason for concern because of the poor rate of acceptance of new technologies, inspite of the efforts and resources allocated to international and national agricultural research.
The need to strengthen the weak links in the long chain between the two units among other issues, was emphasised. The effect of the poor research extension linkages has also been recognised internationally.

Poor coordination between agricultural research and technology transfer units is one of the most serious problems of effective technology production systems in the developing countries (Worldbank, 1985; Snyder, 1986). The problem is often attributed - at least in part - to the administrative location of the activities in separate ministries or institutions (Blakenburg, 1984) or weak linkages between the research and extension functions were identified as constraints to use the research results in 16 out of 20 projects evaluated (USAID, 1982) and the FAO reported in 1984 that all the 12 countries (in which research projects were evaluated) had difficulties of communications between research institutions and extension agencies.

The four cited statements are examples of the seriousness of the problem we have to solve - to make sure, that research results reach the farmers and if they do, that the farmers are able to utilize them for their benefit.

NAES extension approach

What have we at NAES done to create inter-organizational relationships which would assist us in reaching our common goal? Indeed, NAES has made, up to now, considerable progress in the development of new appropriate agricultural technologies: be they cropping practices or new crop varie- ties. Many results of NAES research have been presented to you during this workshop. NAES has also worked outside its boundaries and under-taken farm management surveys and On-Farm Research (OFR) activities in areas in which particular farming systems are practised.

However, provision to fully integrate the research and development, the transfer agencies and the end-user into a so called Agricultural Knowledge and Information System (AKIS) (Röling, 1990; Nagel, 1980) has not yet been made. Röling

describes AKIS as set of agricultural organizations and persons, and links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, inter- pretation, diffusion and utilization of knowledge and information with the purpose of working synergically to support decision making, problem solving and innovation in a given country's agriculture or domain thereof.

To what extent have we at the Nyankpala Research Station, and the organizations engaged in transmission and diffusion created such a complex system?

For efficient delivery, verification and evaluation of research results, NAES at first has created the On-Farm-Experimentation team. It worked for a number of years, sometimes together with the Ministries of Agriculture, but also on its own, in areas of the North of Ghana in which particular farming systems are practised. Likewise, extensive farm management surveys have been undertaken by the economists of the station. For obvious reasons, both groups worked very closly together and even have merged.

The survey activities also involved the transfer and diffusion agencies, but not to an extent that they could be called institutionalized. Members of the Ministries of Agriculture have from the beginning served on committees of the station, i.e. Steering Committee, and the In-house Review meetings.

It is felt that more emphasis must be given to the creation of stronger and even formal relationships which would ensure that links are firmly anchored in an inter-organizational cooperation. As we, the Crops Research Institute, the Ministries and the Non governmental Organizations (NGOs) belong to different organizational set-ups, such a firm relationship becomes even more important.

To this effect, the station has created a so called Liaison Section. Former attempts, to appoint officers at the Ministries of Agriculture did not fully result in the expected relationship either because of lack of personnel or of frequent changes of personnel. It was thought necessary to appoint a section at NAES which would act as the counterpart to all Liaison Officers of the Ministries to make sure, that wishes, proposals and requests brought forward are discussed among the researchers of the station.

Naturally, closest relations have always been with our colleagues from the Ministry at Tamale. On the other hand, our relationship with the Upper West Region, for instance has up to recently been limited to multi-locational experiments of our breeders. The relationship with the Upper East was more intensive, because it is still closer to Nyankpala than Wa.

What is the Liaison Section supposed to do and to what extent can it contribute to the knowledge and information system, we wish to create?

As we are still in the process of getting established, we have provisionally formulated the tasks of the section as follows:

1. Set-up and maintain contacts with governmental and non-governmental organizations.
2. Conduct planning and other technical sessions with the above mentioned organizations.
3. Produce reports on agricultural development and general problems in the regions (for instance on problems our collaborators are facing and which the station could probably solve). Under this heading falls also the responsibility to formulate research proposals to management and to assist management in setting research priorities.
4. Agree with On-Farm-Research and other Sections on activities to be carried out by the Station and make proposals to management.
5. Participate in Research Committee Meetings in order to assist in setting priorities in collaboration with other organizations
6. Foster decision making on activities which will have to be carried out by OFR in close collaboration with management, and conclude agreements with collaborating organizations.
7. Collect research results from On-Station and On-Farm activities and translate them into extension messages - of course again in very close collaboration with the colleagues in the Ministries and NGOs.

What have we done in the section so far?

Contacts with the Ministries have always been there, particularly with the Ministry in Tamale and also in Bolgatanga. We are now in a position to more frequently travel to the regional capitals and to visit our other collaborators to forge even closer relationships and to discuss and agree on problems and programmes we want to implement. We identify our contact men, discuss problems and solve them within our own institutions.

We have also embarked on a programme of joint planning sessions. It started in 1987 when we met with representatives of the MoA at Tamale for two days to evaluate research results. We developed a joint programme of work, and decided on a number of experiments to be carried out jointly. This procedure was repeated in 1988 and 1989. From 1989, we also went to the Ministries of the Upper Regions to meet with them in order to plan our activities. And in 1990, we even managed to have joint planning sessions with the Grains Development Project and our collaborators in the Upper West and Northern Regions, a very substantial step forward in creating a knowledge and information system. This cooperation was made possible because of a number of planning sessions between researchers and management of both places, Kwadaso and Nyankpala. It is hoped that we as a research station can improve our performance if we speak with one voice and have the same messages and do our work jointly. We have

agreed to plan our collaboration in such a manner that we do not compete but cooperate, collaborate and supplement each other in our experimentation and verification work with the Ministries and NGOs.

We believe that these planning sessions should take place ideally during the months of November and December. This timing would enable us, the station, to pass the research proposals and on-farm programmes through our own decision making process until they are finally presented at our In-House Review Meeting. Again, the In-house Review Meeting is attended by the liaison officers of the Ministries and other organizations to make sure the flow of information remains two sided.

We now have a lot of experience from the planning sessions, and we feel that they have been quite useful. However, there is always room for improvement and we are sure that over time we will be able to establish the earlier on mentioned knowledge and information system.

A further step in this direction would be the participation of our collaborators in meetings of the contemplated Research Committe.

To assist staff members of the Ministries, we have started to work on the Agricultural Extension Bulletin. The first four issues have just been published, and we intend to publish many more issues. This Bulletin is also an expression of our very close relationship with the extension agencies and we are grateful for suggestions on how to improve the quality of the bulletin and what subjects should be tackled.

Very high on our priority list of programmes is to assist in the rewriting of the Extension Handbook. I am sure you all agree that this extension handbook is a very useful tool for people engaged in research and extension. We are however, of the opinion that the initiative to start this work should come from the three Ministries and we are very keen to cooperate with you in this endeavour.

As you can see, our relationships with Ministries and NGOs are manifold. Liaison, On-Farm Experimentation and Economics Section, work closely together to make sure that knowledge is generated and information flows. It is our strong desire to improve our performance.

Discussion

H. BAUR

In your presentation you have repeatedly emphasised the role of the OFR section in the field of collaboration, what about the other sections working on the station? How do you see their role in the field of improving linkages?

J. von BARGEN

Other sections, in particular breeders, are already collaborating with ministries in particular at Wa (sorghum, grain legumes) however, participation should always be passed through the Liaison-On-Farm Section in order to be informed about on-going research.

F. ADONGO

(1) What connections do you have with the Information Unit (MoA) which published the last issue of the Extension Handbook
(2) The same unit is in-charge of the Agric. Bulletin; What contact do you have with them?

J. von BARGEN

(1) It has been discussed with the management of the Ministry.
(2) We have to form a joint committee to edit the bulletin. Who is to participate from the MoA, is left to the ministry, it could be Information, Crop Services or Extension.

FACTORS INFLUENCING TECHNOLOGY ADOPTION IN NORTHERN GHANA - A CASE STUDY.

T. KIPO

Nyankpala Agricutural Experiment Station

Introduction

Several field research findings have brought evidence that a wide variety of conventional on-station trial methodologies can be appropriate for assessing the technical viability of a technology. In recent years however, the inclusion of on-farm research trials by researchers developed as a result of the observation that much of the technologies developed from the station trials have not been appropriate and consequently have not been adopted by farmers. The potential role of on-farm research in assessing the socio-cultural and institutional problems of the small scale farmer for the adoption of research technologies is highlighted by several authors. However the viability and sustainability of these technologies under farmers' conditions as well as their adoptability by farmers are determined by a host of factors.

This paper highlights the methods, and findings of an on-farm research trial conducted at Sawla in the Northern Region of Ghana by the Nyankpala Agricultural Research Experiment Station (NAES). It examines how a host of variables of the farming system of an area can influence farmers in adopting or even accepting an On-Farm Research package. It is hoped that the results of this study will form a basis for a feedback for On-Farm as well as On-Station Research activities.

Methodology

The study was based on data from village level surveys and On-farm research trials conducted by the staff of the Agricultural Economics Section and the On-Farm team of NAES since 1983. For the formal data gathering, a special survey was conducted on the adoption rates of the new technologies introduced by the On-Farm research team. In all 45 farming families were interviewed. In addition, information was gathered through informal discussions and through direct observations.

Farming Systems Research at Nyankpala Agricultural Experiment Station (NAES)

The Nyankpala Agricultural Experiment Station (NAES) located in the Northern Savanna Zone of Ghana, is one of the stations of the Crops Research Institute of Ghana. The activities of the station can be put into two main disciplines:

The Crop Improvement Unit and the Farming Systems Unit. The objective of the former is to improve the crop varieties grown in northern Ghana. The Farming Systems Unit, comprising of soil scientists, entomologists and socio-economists engage in

developing adequate cropping systems adapted to the needs of farmers in the station's mandate area.

The On-Farm Research Programme of the Agricultural Economics Section was started in 1983 with thirty (30) villages spread all over the region. By 1986, the region was grouped into four distinct Farming Systems Zones. Seven (7) villages, representing all the zones were selected for On-Farm trials.

The overall objective of the On-Farm Research programme is to test new technologies developed at the Research Station in respect of their feasibility and acceptability to farmers. Costs and returns components as well as the riskness of the new technologies are included. The On-Farm Research team also addresses problems of soil fertility and stresses on the use of organic farm inputs. New technologies such as paired row cropping of cereals with legumes or through relay or alley cropping with pigeon pea were introduced. Emphasis was also on the incorporation of crop residues into the soil.

On-Farm research at Sawla

Sawla is one of the seven villages selected for the On-Farm research programme. According to the NAES classification, Sawla is within the Western Farming System Zone (Diehl, 1986). This area lies in the south-western part of the region, with an annual rainfall averaging 1160mm per year (Kasei, 1988). The soils are generally fertile, and the main crops grown in this area are sorghum mixed with cowpea or maize. Yam growing is also of importance in the area. Cowpea is an important legume crop grown in this area and occupies about 25% of the cultivated area. Yield levels of the various crops are relatively high, reflecting the high level of soil fertility of the area. This may be partly due to the long fallow periods in relation to the length of the cropping cycle, which may be related to the very low population density of the area. Agriculture in this area can therefore be described as being predominantly long term bush fallow rotation.

In an effort to promote the production of cowpea in the Sawla area, NAES introduced a new cowpea variety and modern management practices through On-Farm trials for three years (1985 -1987). The On-Farm team, in developing the technology, struck a compromise between the research station's recommendation and the traditional production practices. This comprised a relay cropping of a new variety of cowpea, Vallenga (IT82E-16) and two new sorghum varieties Loc 29 and NSV -1 including a trial on chemical pest control of cowpea. The trial consisted of three plots made up of the following: One plot was the farmers' own varieties planted under the farmers' own practices; the second plot included the new varieties under the farmers' practices, while the third plot, which for the purpose

of this paper would be called the test plot, contained the new varieties under the complete package of management practices. Below is the layout of the On-Farm trial (Table 1).

TABLE 1: ON-FARM TRIAL LAYOUT IN SAWLA (1986).

(i) Layout: Plot Size: 20m x 20m planted on the flat.
Plot A: New cowpea variety sprayed followed by new sorghum variety
Plot B: New cowpea variety unsprayed followed by new sorghum variety
Plot C: Farmers' practices with farmers' varieties.

(ii) Varieties used:
Sorghum: Loc 29 planted on plots A1 and B1
NSV-1 planted on plots A_2 and B_2
Cowpea: Vallenga planted on plots A and B
Local (wentele) planted on plot C.

(iii) Spraying: A mixture of Roger (Dimethoate at 375 ml/ha) and Decis (at 50 ml/ha) using an Ultra Low Volume (ULV) applicator.

PLOT	A_1	A_2	B_1	B_2	C
VARIETY PLANTED	Vallenga + Loc 29	Vallenga + NSV-1	Vallenga + Loc 29	Vallenga + NSV-1	Local + Local sorghum

Innovation introduced

The technological package introduced at Sawla by the On-Farm team was composed of new crop varieties, planted in line at a higher plant population. The cowpea was to be planted at the spacing of 60cm by 40cm to allow for the intercropping of sorghum. Spraying against insect damage was to be done only twice, at 30 and 45 days after emergence.

Results and discussions

The trials were successfully carried out. The profitability of the innovation was done by making an economic comparison between the recommended practice and the traditional methods.

Table 2 shows the yields of the varieties used for the trial under the various treatments (spraying and no spraying). The results indicated that the improved varieties outyielded the traditional varieties.

TABLE 2: COWPEA AND SORGHUM YIELDS (KG/HA) OF THE ON-FARM TRIALS AT SAWLA 1986

Cowpea	(kg/ha)	Sorghum	(kg/ha)
A. Vallenga sprayed	516	A_1B_1-NSV-1	62
B. Vallenga unsprayed	428	A_2B_2-Loc 29	475
C. Local unsprayed	169	C-Local	420
LSD 5%	139		
CV %	29		

Source: Diehl and Sipkens (1986).

TABLE 3: GROSS MARGINS AND MARGINAL RETURNS OF ON-FARM EXPERIMENT (SAWLA, 1986).

PLOT	GROSS MARGIN ¢	MARGINAL RETURN ¢
A	70,245	46,392
B	69,790	45,937
C	23,853	

Source: Diehl and Sipkens (1986)

TABLE 4: CROP BUDGET FOR COWPEAS - UNDER TWO TECHNIQUES.

		Traditional practice	Recommended practice
Yield	(kg/ha)	200	900
Market price (1988)	(¢/kg)	90	90
Gross value	(¢/ha)	18 000	81 000
Variable costs	(¢/ha)	2 200	24 565
Labour input	(md/ha)	37	60
Gross margin/manday	(¢)	427	941

As can be seen from the results in Tables 2, 3 and 4, the recommended technology was more profitable than the traditional practices

Response

Initially only one farmer participated in the on-farm research trials. By 1984, most farmers had registered to participate in the programme. However not all of these farmers could be selected due to problems envisaged with large numbers of farmers. Moreover the On-Farm research team was unstable as

some members had to leave the country for further training. By 1989, nearly all farmers in the village had access to the new varieties, especially vallenga and were trying the new recommendations.

A. Observation

It was generally observed during the study that there were wide variations in the attitudes and performances among participating farm families. While most farmers weeded their plots late, some even failed to weed at all. Majority of the farmers chose portions of their fields they considered "very poor" for the trials, and about 70% of them worked on their "own" fields before working on the trial plots. The differences in the attitude of farmers gives rise to the assumption that some farmers expressed interest in the trial because it assured them of access to improved inputs, which were generally in short supply, rather than being genuinely interested in the potential of the recommended technology.

B. Adoption rates

The decision by the farmer to choose a technology is determined mainly by riskiness of the technology, compatibility with his socio-economic situation, yield distribution, input supply situation and availability of product markets.

Although the profitability of the practices introduced by the on-farm team over the traditional technique is clearly demonstrated in Tables 3 and 4. The study showed a wide disparity among farmers in the type of innovation adopted. For the purpose of this paper, adoption is defined as the willingness and ability of a farmer to use/or apply an innovation to his conditions as received. Thus a farmer might accept an innovation but might not be able to adopt it. The ability to adopt, and the incentive to utilize technologies generated is not simply a reflection of perceived needs and access to resources, but also a question of the institutional arrangements within and between households which govern access to and allocation of resources. (Francis and Atta-Kra, 1989). The new technologies seemed to meet the needs and preferences of the farming community. Nevertheless, the adoption rates were low and farmers continued to use their traditional methods (Table 5).

TABLE 5: DIFFUSION OF INNOVATION INTRODUCED.

INNOVATION	No. OF FARMERS ACCEPTING	No. OF FARMERS ADOPTING
Cowpea (vallenga)	45	28
Sorghum (NSV-1)	0	0
Sorghum (Loc. 29)	40	0
Row planting	45	10
High plant density	45	9
Spraying	32	3

The reasons for adoption or non-adoption of the various components of the improved package are discussed below:

Recommended varieties

The introduction of the new sorghum and cowpea varieties was an important technology, considering their significance in the economy of the area. All farmers accepted that Vallenga and Loc 29 were better than their own varieties. First of all these introduced varieties out-yielded the local types even under unsprayed conditions as well for cowpea (Table 2). In the second place, 80% of the farmers mentioned that Vallenga boiled quicker and tasted better than their own varieties. Thirdly, and most important to the farmers was that Vallenga matured a little earlier than the indigenous types and was therefore the first crop ready for harvest in the farming year. This helped to close up the hunger gap.

In spite of the potential of the introduced varieties, their adoption by farmers was not encouraging. Only 28 (62%) of farmers adopted and continued to grow the new cowpea variety. However the new varieties of sorghum were not adopted even though they out-yielded the existing varieties. The variety Loc 29 gave about 13% higher yields than the farmers' variety. Unfortunately, the yield of NSV-1 was difficult to assess because it matured too early and most of the grain was lost through the effects of the rains. The low adoption or non-adoption of these technologies demonstrate the prominent role that farmers' risk aversion plays in determining the choice of a technology. The farmer would allocate his scarce resources first to his own practices before any other technology for which his knowledge is at the threshold level.

The main reason for lack of adoption of the new varieties was lack of seed. Although quality seed is important for attaining high levels of productivity, its timely availability is a major factor. The on-farm research team could not meet the seed demand, and the little seed retained by the farmers could not be well stored, resulting in poor germination.

Row planting and high plant density: All farmers accepted that row and close planting, though tedious and time consuming, gave high yields. Close planting also gave high plant density and a quick ground cover which, according to farmers, reduced labour requirements for weeding. Twenty-six (58%) of the farmers said they accepted row planting because that made the fields look beautiful.

The adoption of any technology by small-scale farmers of Northern Region depends among other things on the adaptability of the new technology to the farming systems and socio-cultural conditions of the community (Ibrahim, 1986). The recommended plant density and the use of garden lines for row planting were major changes in the cropping pattern of the area. Consequently, the adoption was low for these components of the technological package. Most participating farmers did try to plant closely and in line, but it was not as well as expected. Another constraint was the high input of labour required for close and row planting.

There was lack of participation by women in the trials. This gave rise to the assumption that the researcher had insufficient knowledge of how the production system in the area is organised at the household level. Within the traditional production system in the area, there is a well defined division of labour. Although men are considered owners of farms and were registered as participants of the On-Farm research programme, women were exclusively responsible for planting all crops except yams. The absence of women as participants reflected on their attitudes to and expectations of the new technology of row and close planting and consequently had important implications on the adoption rate. As stated earlier, high plant densities in rows is a major change of the farming practice. The practice of low plant densities can be understood as the general pattern of crop production in mixed cropping. The facts received on the tedious and time consuming nature of row and close spacing was got from the wives of participating farmers.

Farmers did not favour high plant densities because the cowpea under high plant densities, soon covered the ground and left no room for the intercrop of sorghum - the staple crop. Although the On-Farm recommended practice was an intercropping technology, the time recommended for the intercrop of sorghum does not conform with the cropping calendar of the area. Traditionally, sorghum is planted almost a week after or together with cowpea. However the recommended practice required that sorghum should be planted two weeks before cowpea harvest. This problem could be solved by developing varieties and a set of recommended practices that would permit early planting.

(iii) Spraying: Although all farmers are aware of cowpea's susceptibility to insect pests, the results of the study reveal that chemical pest control was least accepted, not to mention adoption. Only thirty-two of them adopted the technology.

The potential of any variety cannot be fully realised unless farmers have access to other inputs that go with the variety and unless all these are used according to the recommendations of the manufacturers. Since the high yield of cowpea depended a lot on the use of chemical pest control, the absence of insecticides affected the adoption of the other components of the innovation. One important factor influencing the low adoption of spraying was the importance of cowpea leaves. These are used for preparing soup and other foods in this area. The use of chemical pesticides constitutes a health harzard. Other factors for the low adoption included the input situation in the area. The input distribution system prevailing at that time could not provide the needed inputs. Even if these inputs were available in their right quantities, adoption would still be slow or non-existent because buying the equipment for spraying is a life time

investment, considering the annual cash income of the average farmer. The cowpea package depended on spraying material and all packages required information. This constituted a major constraint. Farmers in the area do not know how to handle and operate spraying equipment. Success in the adoption of spraying will involve training the farmers in these new techniques.

Conclusion

Any strategy that would increase productivity and income of the small scale farmer would be welcomed by farming households. The present study reveals that a technological package introduced by On-Farm researchers, though profitable and meeting the requirements of the farmers of the area, was adopted with little enthusiasm. Although farmers agreed that most of the technologies introduced could help raise their standard of living, there was little diffusion of the innovation. However, the little adoption of the introduced practices received, is understandable, considering the complex environment in which the farmers operate. There were a number of problems identified by farmers during the adoption process. Important among these were, the position of cowpea in the dietary habits of the farming population, the unavailability of insecticides and improved seed, risk aversion, general lack of knowledge about the use of the equipments and division of labour within the farm household.

Inspite of the little adoption of the technology, the vital role played by cowpea in providing a balanced diet for the people need to be addressed with more seriousness. To achieve increased agricultural productivity, for the ever-growing population, a realistic innovation transfer model should be designed. This model, should be low cost, involving the use of as much local resources as possible and more importantly, it should be consistent with the farmers' natural and economic circumstances, and be able to fit into the existing farming system. Such a model could be financed by credit for farmers with access to the inputs and suitable management skills.

Research scientists should work towards identifying crop genotypes with some level of resistance to insect damage and agronomic practices that suppress insect attack. This strategy would be effective for developing appropriate technologies that will be more readily adopted by the farmer.

References

Diehl, L (1986). Smallholder Farming Systems in Northern Ghana. Paper presented at the first workshop on Improving Farming Systems in the Savanna held at Nyankpala, Ghana April 8-10, 1986.

Diehl, L and L. Sipkens (1987). Results of 1986 On-Farm Experiment. Paper presented at the 7th National Maize and Cowpea Workshop held in Kumasi, Ghana, February 3-5, 1987.

Ibrahim, A.R.S. (1986). Diffusion of Innovations among smallholders in Northern Ghana. Paper presented at the first workshop on Improving Farming Systems in the Savanna Zone held at Nyankpala, Ghana April 8-10, 1986.

Francis P.A. and Attah-Kra, A.N. (1989). Sociological and Ecological Factors in Technology adoption. Experimental Agriculture, 25: 1-10.

Kasei, C.N. (1988) The Physical Environment of Semi-Arid Ghana. Paper presented at the first conference on Dryland Farming, Texas, U.S.A.

Kipo, T. (1989). Sociological Characteristics of Small-holder Farming Systems of Northern Region of Ghana. Paper Presented at the 2nd Symposium of West African Farming Systems Research Network held in Accra, Ghana on 28th August - 1st September 1989.

Discussion

O. ABDEL-RAHMAN

Differentiate between acceptability and adoption of innovation and explain how these were measured.

T. KIPO

Accepting an innovation may be considered to be agreeing on the principles that it works. Adoption can be said to be the willingness and ability of an individual to use/or apply an innovation to his conditions as received. Thus an individual might accept an innovation but might not be able to adopt it.

T. del GUIDICE

The precondition for a farmer to adopt a new technology in his specific farming system is the availability of the inputs needed for that new technology. Shouldn't we take this economical constraint into consideration before developing new technologies?

T. KIPO

This is one of the ideas my paper is dealing with. It is not just the availability of the input that should be considered, I think the cost and timeliness of the supply of the input are major factors.

F. I. MUMUNI

It is said that the leaves of the local cowpea are consumed by the farmer. Farmers also use part of the (pod) harvested green. Were these aspects taken into consideration in arriving at the yield comparisons in the trial?

T. KIPO

Yes. The quantities of leaves and green pods consumed or sold by the farmer were costed.

J. GYESEY

Culture influences adoption of innovations or technology. How do (i) norms (ii) values (iii) attitudes affect the social change of the farmer?

T. KIPO

Norms, Values and attitudes are interelated, and greatly influence the social change of the farmer.

Individuals' decision making processes are rooted in their understanding of social norms and beliefs. An individual may refrain from accepting a social change where he/she perceives that the change may bring personal gains but threaten security or status within the community. Community norms at times exert powerful deterrent forces against innovations and individual initiatives.

CONSTRAINTS TO INCREASED PRODUCTIVITY ON IRRIGATION PROJECTS

K.M. SETSOAFIA,

(Vea Irrigation Project, Bolgatanga)

Introduction

The World's irrigated area almost tripled between 1950 and 1982. Although it represents only about one-sixth of the World's cultivated area, it supplies one third of the World's food crops. Production growth rates and increasing food requirements will further increase humanity's dependence on irrigated agriculture (Cernea, 1985).

This assertion contributes greatly to efforts in Ghana to promote irrigation as a means of increasing food production and avoiding crop failures.

The total area developed for irrigation in Ghana is about 10,000 ha (FAO, 1986). This represents only 8% of the total potential area available for irrigation and about 0.3% of our total erable land. The role of irrigated agriculture in food production in Ghana is thus minimal. However, in line with current agricultural development plans of many developing countries in sub-Saharan Africa, huge investments have been made in the construction of dams and irrigation projects in Ghana.

Like many other developing countries, despite these huge investments and the considerable potential of irrigation projects, many of them have failed to live up to expectations.

It is now recognised that many of the causes of these failures are not technical, but results from inattention to the social organization of the irrigators and fundamental weaknesses in the human process of planning and management (Cernear, 1985; Botrall, 1985). Consequently, farmer participation in the operations and management of irrigation projects is minimal leading to the non-achievement of objectives.

Three broad categories of factors appear to be most important for possibilities and productivity of farmer participation (Uphoff, 1986):

(i) Historical factors that affect farmers' willingness and ability to assume responsibility for various irrigation task
(ii) Physical and economic factors that shape the supply and demand of water, thereby affecting water users' orientation toward collective action and
(iii) Socio-cultural and political factors that influence the water users to relate to one another and to the government.

This paper examines these factors and their effects on farmer participation in the operations and management of irrigation projects in Ghana. Agricultural development can only be promoted and sustained when supported by an appropriate research programme. The effects of the non-existence of any meaningful research progamme to support agricultural development and sustenance of our irrigation projects shall also be discussed.

Historical factors

The knowledge and skills which water users can bring to the tasks of management, as well as their disposition to accept responsibility, will depend a great deal on the origins of each irrigation system (Uphoof, 1986).

Most irrigation projects in Ghana have been sited in areas where farmers lack the requisite knowledge and skills to make irrigated agriculture profitable. Two main systems of irrigation are used to deliver water to fields in Ghana:

(i) Through canals and laterals by gravity/pumping machine
(ii) Through pipes and sprinklers.

Before the introduction of these technologies, dry season farming was done by fetching water from wells or through recession water. Thus they were not used to these new systems of irrigation which they were supposed to operate. Training them to acquire the knowledge and skills to operate these systems has been neglected and thus farmers were left with little command over these new technologies. This has led to the inefficient use of water and poor maintenance of delivery systems observed on most of the irrigation projects.

In addition, these water delivery systems require collective efforts for efficient operations. Irrigation projects are usually complicated and difficult. First of all, the farmers must be well organised and able to work together exceptionally well. Our farmers normally undertake rainfed farming which requires no collective effort for water acquisition, delivery or use. This attitude towards rainfed agriculture where every farmer carries out field operations at his own convenience is extended to irrigation projects. Collective action needed for successful operation and management of irrigation project is thus absent, as there is no co-operation among farmers.

Furthermore, our irrigation projects have been set up using the "top-down" approach to development. Most of the projects have been designed and established on the basis of physical conditions in the area. As a result, it is doubtful whether the project is really satisfying the needs of the people. There is hardly any time allocated to consultation with the intended scheme farmers in order to secure their involvement and to prepare for their training (Kortenhorst et al, 1988) giving further credence to the notion that in most parts of the world higher status people do not listen to lower status people (Axim, 1988). This has proven to be a severe danger to the sustainability of development projects in this country, irrigation or otherwise.

The Tono Irrigation Project is still underutilised since its' completion about 5 years ago because of this lack of consultation with the intended beneficiaries. Non-commitment to the achievement of objectives by farmers is further seen by intentional damages to canals and laterals and damages to crops by animals while farmers look on unconcerned.

Physical and economic factors

These factors shape the supply of and demand for water, and thereby affect water users' orientation toward collective action. Where water is abundant, there may be little or no need for collective effort to acquire, allocate and distribute. Thus we find that in irrigation projects with reservoirs with low storage capacities (e.g. Bugri, Gagbiri), farmers participation in the operations and management are higher than on irrigation projects with large reservoirs, e.g. Tono and Vea.

Furthermore, in recent times, to enable the government recover some of the cost incurred in the establishment of irrigation projects, farmers are charged for water. In Ghana, these charges are based mainly on size of areas cultivated, and not on amount of water used. Thus water users tend to treat the water as inexhaustible and thus no efforts are made to conserve it or to be collectively responsible for its efficient use on laterals.

In addition land tenure systems, farming systems, marketing facilities, economic activities have been observed as other physical and economic factors that affect the degree of farmer participation and increased productivity.

Land tenure systems

Management of developed lands is perhaps the most difficult problem in the management of irrigation schemes (Belloncle, 1988). Land arrangements can affect both the willingness and ability of water users to participate in irrigation management. In Ghana, this appears to be the major constraint to increased production and project sustenance, as tenants with secure claims to the land they cultivate are usually more willing to contribute to permanent capital improvement in irrigation systems. At Gagbiri irrigation project, near Bawku, e.g. farmers are contributing money to reconstruct their spillway - a capital investment. This is attributed to the fact that farmers on this irrigation project (25 ha) own the land on permanent basis and thus they view the project as their own. Similarly, at Bugri irrigation project (about 50 ha in size), where land is also owned on permanent basis, farmers undertake all repairs and maintenance of laterals and canals. This is in contrast to what pertains on larger irrigation projects, e.g. Vea and Tono where major capital improvement or remedial works have to be carried out by the project staff with government funds. Farmer participation in or their commitment to achievement of objectives on these larger irrigation projects is poor due to the land tenure system which offers them no security to the land, and therefore no incentive to undertake activities that will sustain the project.

At the Vea irrigation Project, the land is farmed by the original owners (before the development of the scheme) in the wet season and in the dry season land is allocated to other farmers.

Changes in land ownership delay early cropping and cause the project not to plan effectively or implement plans with the farmer, as one of the major resources (i.e. the land) is beyond the control of the farmer. A major consequence of this inability to plan or implement plans is the yearly glut experienced with tomato production on the Vea Project.

To encourage participation in operations and management of the Vea Irrigation Project, responsibility for land allocation has been given to village committee executives of the eight village farming communities with effect from the 1988/89 dry season. Similar arrangements exist on the Tono Irrigation Project but land allocation is done on seasonal basis by the village committee executives. The projects have however, retained a portion of the land for commercial farmers. Until recently, Bontanga also allocated land on seasonal basis - but has shifted to a semi-permanent basis where land is allocated for a period of four seasons.

Security to the land also enables farmers to carry out agronomic practices that promote agricultural development and sustainability. A survey of agronomic practices carried out on four irrigation projects showed that farmers on Bugri and Gagbiri projects undertook practices that enhance soil fertility (e.g. mulching, application of organic manure) on their irrigated fields. Tono and Vea farmers carry out these practices on fields outside the irrigation project. This is once again a reflection of the type of land tenure system existing on each of these projects.

The land tenure system at Tono and Vea places emphasis on "production agriculture" and can be termed "mercenary farming" where the focus is on maximum yields in the short run, regardless of the cost to the future of the agriculture land base.

The security to land on some of the irrigation projects has led to underutilization of land especially during the wet season. Farmers prefer to acquire land in nearby areas for farming to avoid payment to irrigation projects with abundant land. The objective of increased productivity through increase in cropping intensity (i.e. more crops produced in a year) cannot therefore be achieved.

Farming system

It has been observed that many planners treat irrigation schemes as isolated entities. However, in the eyes of the farmer, these schemes are only part of his farming system. This is because our peasant farmers who are the beneficiaries of these schemes have other farming activities to undertake. Thus one finds on some irrigation projects the development of land for cultivation of rice which many of the beneficiaries have had little experience with. This leads to the abandonment of such irrigation projects by farmers to the areas in the wet season to cultivate food crops to sustain his family - a major objective in peasant agriculture.

In Northern Ghana, where the topography and vegetation are very suitable for irrigation development because of its flatness and absence of trees, many farmers rear livestock. Unfortunately, this important component of the farming systems in this part of the country has been neglected in our irrigated agriculture. Is it not an irony that livestock in villages sorrounding irrigation projects have to survive long periods during the dry season without adequate feed? Much production time is therefore wasted during dry season cropping to protect crops from destruction by animals which are left to roam about on their own in search of feed.

Irrigation projects need to integrate into their operations, programmes to ensure adequate feed for animals throughout the year and proper animal husbandry activities, e.g. construction of paddocks to house the animals for easy collection of manure for fertilizing field crops, and development of pastures. The operations of some of our irrigation projects are contrary to the basic principles and practices of peasant agriculture, which integrate crop production and animal husbandry. The ignorance of the planners about the farming systems on the sites creates some of the frequent problems on irrigation schemes (Belloncle, 1988).

Marketing facilities

Effective farmer participation cannot be expected if there are not market avenues for the farmer to sell his produce at the end of the season. Increased productivity can only be achieved through effective marketing research and strategies that promote increase in farmers income. The income of a farmer is best determined not at the point of production but rather at the point of marketing. Farmers will participate more effectively in the management of irrigation projects if markets are readily available and their produce can be purchased at prices that bring profits. Seasonal gluts in tomato production on the Vea and Tono projects due to lack of market are a major constraint to increased productivity on these projects. Farmers during this period are unwilling and not motivated to even attend meetings or carry out any maintenance works as they keep on chasing the Makola women for crates. Irrigation schemes which ensure higher incomes for farmers' produce shall be more sustainable than those which promote production without the supporting market. This is because farmers would be more willing to pay for maintenance costs on the former than on the latter.

Economic activities

The tenancy arragements have created part-time farmers or absentee farmers on most of our irrigation projcets. These farmers do not have much stake in operating and maintenance of the irrigation system competing demands from their other economic activities tends to affect their effective participation in certain management activities.

Socio-cultural and political factors

The need for farmers on irrigation projects to be well organised and be able to work exceptionally well has been well documented. The water flowing in an irrigation system is so much a social product of human organisation as it is a natural commodity. This is because people must organise socially to secure water, transport it, divide it into usable shares, enforce rules for its distribution, pay for it, and dispose of its unused portion (Cernea, 1985). It is now recognised that the difficulties that irrigation projects face in their operations and management are not technical, but have resulted from inattention to the social organisation of the irrigators.

Organisation makes participation patterned and predictive enough to acquire some recognisable and productive structure (Uphoff, 1986). In addition to social organisation, indigenous forms of leadership provide basis for co-operation among water users.

Wide variations exist among water users on our irrigation projects. These variations are due to different levels of literacies and different ethnic backgrounds. These are very common in larger irrigation projects which because of their size cover areas belonging to farmers with different ethnic backgrounds (e.g. Tono). In addition, on these projects can be found different classes of farmers - commercial, peasant, literate and illiterate. These differences affect the degree of co-operation among farmers which is very essential for effective participation. The non-cooperation existing among farmers on irrigation projects is a contributory factor to the existence of major agricultural problems on many of our irrigation projects. Wide-spread incidences of diseases are not easily combated as farmers tend to undertake control on individual basis rather than on co-operative basis. The yearly glut of tomatoes experienced on the Tono and Vea Projects and the easy manipulation of prices by the Makola women from Accra are due to the non-existence of a well organised group of farmers. In contrast, the Makola women are a well organised group and are thus able to plan their purchases so as to maximise their profits. Political ideology can have an equally important influence on co-operation between farmers and an irrigation agency. One of the main deterrents to farmers assuming or accepting more responsibility for irrigation management is the orientation of the agency personnel with whom they must work. Too many of the irrigation staff, whatever their competence, appear unwilling to work respectfully, seriously and fairly with water users in a joint enterprise of improved irrigation mangement (Uphoff, 1986). These are due to differences in attitudes, values and beliefs between irrigators and the irrigation staff. People who are similar in above attributes tend to form stable enduring groups (Handy, 1976).

Team spirit among irrigators and irrigation staff on the irrigation projects is very low, and is even responsible for the non-co-operation among farmers.

Organising for collective action is a demanding and problematic undertaking and water users can be fairly easily discouraged from investing in developing groups.

Irrigation research

Agricultural development can only be sustained if it is supported by an appropriate research programme. Regrettably, in this country there exists at present no programme to support agricultural development on our irrigation projects. Irrigated agriculture is a complex science and farming on the irrigation projects is very intensive. More difficult agricultural problems (e.g. high incidences of pests and diseases, soil degradation) therefore occur with irrigated agriculture than with rainfed agriculture. These demand that an irrigation research programme be set up to help irrigation projects solve their production problems to sustain agricultural development and increase productivity.

Conclusion

The failure of many of our irrigation projects to sustain a high rate of agricultural development is due to inadequate institutional development and a lack of farmers' participation in the management of the schemes. Another factor is the lack of a supporting irrigation research programme.

Land tenure arrangements on our irrigation projects however, militate against institutional development and the participation of farmers in the management of the schemes. Ownership of land is a powerful incentive for effective participation by farmers for sustenance of the schemes. Farmer participation in the management of irrigation projects is thus higher on smaller irrigation projects where land is owned on permanent basis. The decision of the government and donors to develop small-scale irrigation projects rather than large scale irrigation projcets is in recognition of the difficulties encountered in the management of these projects. The World Bank in a recent report stated that lack of good management is the primary reason why so many projects fall below their potential.

Much investment has been made in the establishment of irrigation projects. This calls for further investment in management training for key project staff if the projects are to achieve their objectives. Management of irrigation projects for small-holders is, however, complex and difficult as unlike in commercial farms. The irrigation project manager has little control over the ultimate producers - the farmers. These are the people on whose activites he must depend for the achievement of his objectives. Inter-dependence among farmers and between farmers and irrigation staff is therefore very essential for the success of any irrigation project.

References

Axim, G. H. 1988. Training and Visit (Tragic and Vain) Extension. Interpake Interchange, pp. 6 - 7, University of Illinois at Urbanar Champaign.

Belloncle, G. 1988. Is user Participation in Irrigation Schemes possible. In Proceedings - Irrigated Agriculture In Africa, Harare, ed. Steekelenburg, P.N.G. pp. 81 - 94.

Cernea, M. M. 1985 ed. Putting people first - Sociological Variables in Rural Development, pp. 27 - 25. World Bank Publication, Washington D.C.

Handy, C. R. 1976. Understanding Organisations. Hazell Watson and Viney Ltd, pp. 156.

Kortenhorst, L. R.; L.H. Sprey, P. N.G. Van Steekelenburg, 1988. Some Aspects of Irrigation Development in Sub-Saharan Africa.
- In Proceeding - Irrigated Agriculture in Africa, Harare, ed. Steeklenburg, P. N. G. pp. 37 - 80.

Uphoff, N. 1986. Improving International Irrigation Management with Farmer Participation. Getting the Process Right. Studies in Water Policy and Management, No. 11, Westview Press.

Discussion

E.A. ADDISON

The speaker made some pronouncements which give cause for concern, e.g. lack of cooperation between staff and farmers, absence of any meaningful research at the sites. Who runs these irrigation schemes and what are your proposals for improving the situation?

K.M. SETSOFIA

With the exception of Tono and Vea projects, which are managed by the Irrigation Company of Upper East Region (ICOUR), all other irrigation projects are managed by the Irrigation Development Authority. We have to accept that work done by the irrigation staff lack the requisite manager to manage these projects effectively.

This is well documented. Quite often, engineers are asked to manage their schemes. There is thus always a conflict between the engineers and the agriculturist in these projects. Agriculturist by virtue of their training in extension appear to be better equipped for managing their schemes.

I propose that irrigation manager/staff be given adequate training in management and social science to better understand the social organisation of irrigation schemes for effective management.

R.D. ASIAMAH

Why are lands not allocated to commercial farming but instead to locals who have no knowledge in irrigated rice production?

K.M. SETSOFIA

Allocation of land to commercial farmers, leaving out the locals, brings about resistance from the locals to the activities and properties of these commercial farmers and the projects itself. Thus one finds destruction of commercial farmers' fields by animals and destruction of laterals and canals by the locals.

O.A. APULLAH

COMMENT: (i) Lack of cooperation from farmers is due to denial of land allocation to farmers (indigenous) at project site. (ii) Involvement of farmers in planning and implementation of irrigation programmes is necessary.

K.M. SETSOFIA

I mentioned in my presentation the lack of consultation with the farmers at planning and design of the projects. If this is done, there would be better understanding of the land tenure system in the area, and land tenure arrangement could be put in place which shall promote farmers cooperation. Effective management of irrigation projects calls for farmer involvement in the planning and implementation of irrigation projects.

The constraints that I have stated are meant to throw more light on why irrigation projects fail to achieve such objectives and also for us to share ideas so that together we can make suggestions to improve the management of our irrigation projects. Thank you.

I.K. LANGMAGNE

Poorly organised farmers could not relate to farmers accepting the technology but failing to adopt the technology. Are there any suggestions to improve on the land tenure system?

K.M. SETSOFIA

(i) At the time of the establishment of irrigation projects, there are generally no surveys to find out the knowledge and skills of farmers to determine if the technology shall be acceptable to them. Thus even if the farmers accept the technology, they lack the requisite skills and knowledge to adopt the technology.

(ii) There is the need to review the land tenure system so as to reflect more of security than insecurity to land ownership. In Bontanga, there is at present a shift from the seasonal allocation to an allocation which gives the farmer ownership for at least four seasons.

A.S. LANGYINTUO

Technology adoption on farmers level is gradual and late adoptors obtain their decision from the experience of early adoptors. Has there been any survey to find out if there has been an increase in adoptors? If no, please do.

K.M. SETSOFIA

On the Tono and Vea Irrigation projects we have the Monitoring and Evaluation Unit which monitors the adoption rate of extensionists' recommendations to farmers. Increases have been found in adoption of (i) rice transplanting in rows, (ii) use of fertilizer, (iii) use of improved rice varieties.

AN INTEGRATED RESEARCH APPROACH FOR A SUSTAINABLE AGRICULTURE IN THE SAVANNA ZONE

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Introduction

Area

The Savanna occupies about 41% of the land mass of Ghana (i.e. 97 000 km^2 out of the total of 239 000 km^2). The Northern, Upper East and Upper West Regions of Ghana constitute the savanna zone.

Vegetation

Being in an agricultural zone, the savanna is characterised by grassland, short drought and fire tolerant trees which are sparsely distributed.

Soils

The soils here are mainly savanna ochrosols which are very fragile in nature and prone to environmental degradation. In general savanna soils are of low inherent fertility except hydromorphic or valley bottom soils. Soil fertility is maintained by fallowing.

Population

According to 1984 population census, about 20% of Ghana's population live in this zone. It has a population density of 42 people per square kilometre compared to 51 people per square km nationally. It, however, ranges between 17 in Northern Region through 24 in the Upper West Region to 87 in the Upper East Region.

Occupation

Over 90% of the people here are living in rural areas and are mainly small-scale farmers with average holdings ranging between 1/4 of a hectare to 5 hectares. These could be higher in commercial rice and maize growing areas.

The savanna zone is normally refered to as the granary of the nation since most of the cereals (rice, sorghum, millet and maize) and grain legumes (cowpea, groundnut, bambara groundnut and pigeon pea) are grown in this area.

The savanna zone is a major yam producing area. Some cassava and potatoes are also produced.

It is, however, regrettable to state that except in some few cases the average yields of these crops are still very low. Table 1 shows yields of some commodities grown in Africa compared with the world average yields.

TABLE 1: MEAN YIELDS (T/HA) OF VARIOUS COMMODITIES GROWN IN AFRICA AS COMPARED WITH THOSE OF THE WORLD IN 1985

CROP OR COMMODITY	YIELD (T/HA)	
	WORLD	AFRICA
CEREALS	2.52	1.08
Maize	3.48	1.13
Rice	3.22	1.74
Sorghum	1.54	.75
Millet	2.22	1.19
ROOT AND TUBERS	12.45	7.57
Cassava	9.62	7.55
Yams	10.47	10.01
Sweet Potatoe	13.92	5.71
GRAIN LEGUMES	0.75	0.47
Beans (cowpea)	0.58	0.72
Groundnuts (in shell)	1.12	0.76
Soya beans	1.91	0.91

SOURCE: FAO Production Year Book 1986 (OKIGBO 1988)

In livestock production the savanna zone supports about 60% of the ruminant population and leads in the free range keeping of pigs, chicken and guinea fowls. Like crops, the potential of livestock industry is great, but the limiting factors like breeds, nutrition (especially the hunger gap period of the long dry season), diseases and pest are many.

The question now is, what are the bottle necks to the achievements of these potentials of the savanna zone?

These can be summed up as follows:

1. Problems of soil fertility,
2. Unimproved varieties of crops and breeds of animals,
3. Lack of appropriate tools,
4. Lack of appropriate agronomy and husbandry techniques,
5. Other problems which indirectly affect agriculture - credit facilities, infrastructure, pricing and socio-political problems.

Factors limiting the achievements of potentials of the Savanna Zone

Soils:

Soils are the basis for any agricultural development. As stated earlier, savanna soils are generally very fragile and low in fertility. Soil fertility maintenance through shifting cultivation which used to characterise low population areas is now ineffective due to increase in population density.

The soils are being exposed at a faster rate by clearing vegetation as a result of the following:

1. Intensive cultivation leading to shorter fallow periods due to high population pressure,
2. Overgrazing and burning by herdsmen and hunters exposing soils to agents of erosion,
3. Bush fires - exposing the top soil to degradation,
4. Fuel wood - the unprecedented firewood scarcity is occuring in the savanna zones (there are ever increasing shortages of trees near settlements),
5. Improper land clearing and land preparation.

The magnitude of the problem caused by population growth might be underestimated, but the picture will come out clearly if reference is made to the 1984 census (Table 2).

TABLE 2. POPULATION GROWTH CHANGES 1960 - 1984

	NATIONAL	OTHER REGIONS	NORTHERN SAVANNA
RATE/YEAR (%)	2.6	2.5	2.7
POPULATION DENSITY/KM^2			
1960	28	60.1	23.7
1970	36	83.9	29.3
1984	51	42.03	42.7
Overall % increase	13	7.4	31.7

Northern Ghana has a growth rate of about 2.7% compared to 2.6 and 2.5 nationally and other regions in that order. The national population density changed in 1960 from 28 to 36 in 1970 and then to 51 persons per km^2 in 1984. In other regions it changed in 1960 from 60.1 to 83.9 in 1970 and then to 42.03 in 1984 while in northern Ghana it changed in 1960 from 23.7 to 29.3 in 1970 and then to 42.7 in 1984.

The overall changes over the period were 13%, 7.4% and 31.7% nationally, other regions and northern Ghana, respectively. The trend might continue if demographic measures are not taken to reduce this problem. This I have doubts whether it can be controlled within the foreseeable future. Other measures will have to be adopted to contain the land pressure problem.

Varieties of crops and breeds of livestock

The varieties of crops and breeds of livestock used by farmers in the savanna zone although stable, are genetically low yielding and unadapted to efficient production under modern technology.

Research in plant breeding has in recent years had spectacular results in maize, cowpea and rice which led themselves to monoculture. However there has been too little effort for the improvement of traditional varieties of food crops such as sorghum and millet and the farming systems using these crops. This is a reflection of the relatively poor support that has been given to or by institutions working on these crops. Sorghum and millet are still the first cereal grains in Upper East, Upper West and certain part of Northern Region. Maize and rice have only become popular over the last 15 - 20 years in Northern and only about 5 - 10 years ago in the sister regions.

Emphasis should be placed on the small-scale farmer since little would be achieved by transforming the small scale farmer into a large-scale farmer due to the land hunger. The experiences of the "Operation Feed Yourself" (O.F.Y), State Farms, Food Production Corporation, the Green Revolution and other bases of large-scale farms should not be forgotten.

There has been very little attempt to improve upon the small and slow growing breeds of cattle in this zone, although the environment and a well managed range pasture can support improved breeds especially those from neighbouring savanna and sahelian zones.

Lack of appropriate tools

There is the widespread use of simple tools like the hoe and cutlass, since farmers cannot afford tractor services. The second most valuable output of livestock in agriculture is animal traction, yet it is estimated that less than 10% of farmers make use of draught animals although the savanna zone holds about 60% of the livestock population in the country. This could reduce the seasonal labour shortages for timely land and field operations. Draught animals could also reduce the damage done to soils by heavy machinery and surplus labour can be used for other income earning activities.

General lack of agronomic/husbandry techniques

Certain practices used by farmers are sometimes inappropriate in the farming systems. The selection of sites and the use of varieties are not valued much. Farmers often do not take into consideration the nature and slope of land and for that matter are faced with drainage and erosion problems.

Techniques and methods of planting within a growing season are often done with greater risk. The serious problems posed by weeds in reducing farmers yield normally result in fallowing, but once this system can no longer be tolerated under the present circumstances, there is the need to replace this either by mechanical, chemical, manual or by any other means of weed control.

The problem of harvesting and post harvest losses is persistent. Apart from insect pests and diseases of cereals and grain legumes, granivorous birds, e.g. Quelea quelea cause serious annual losses in grain crops like sorghum, millet, rice and maize in the savanna zone. What are the researchable solutions?

The problem of ecto- and endoparasites of livestock are normally reduced by routine spraying/dusting while cases of sporadic occurrence of anthrax, rinderpest, black leg and others are reduced by routine vaccinations.

Other agricultural production bottlenecks in terms of credit, fertilizer, infrastructure, pricing and socio-political ones cannot go unmentioned. What then are the strategies to be adopted?

Possible suggested strategies

Two optional methods may be adopted for a sustainable agricultural production in the savanna zone, viz. (1) increasing the land under cultivation. (2) intensification of the land under-cultivation.

In choosing alternative (1) the result is further destruction of the vegetation and for that matter the soil under cover. The high population pressure as observed earlier on cannot allow this strategy since the land area available for further expansion is limited and long fallows can not be tolerated any longer.
Furthermore, the machinery and investment for expansion of land under utilization is limited.

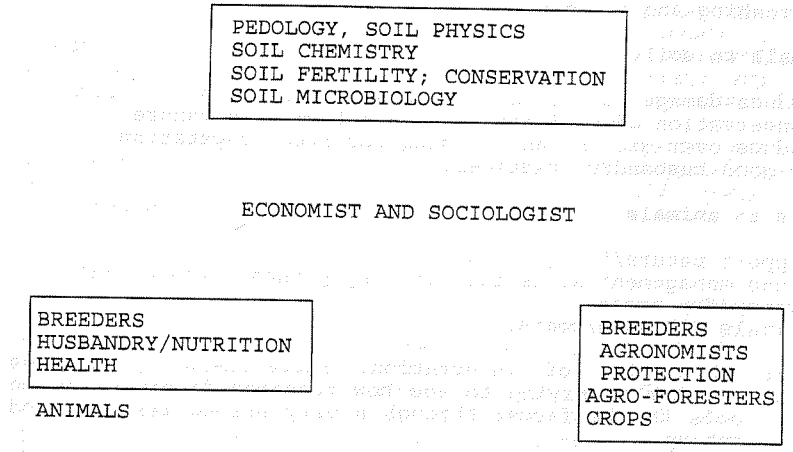
Bearing in mind the above, the savanna zone is therefore faced with a situation where it has to make do with land saving strategies and the management of smaller land holdings. This leaves us with alternative (2). "An integrated Research Approach" will have to be adapted under this strategy. How does this look like?

Research proposals will have to integrate soils, crops and animals in such a way that the environment can be protected while at the same time a sustainable agricultural growth is maintained. This might be summed up as:

a. Soils - Crops - Sustainable Animal production
b. Crops - Animals - Sustainable soil fertility
c. Animals - Soils - Sustainable crop production

This can be diagrammed as in Figure 1.

FIG. 1: DIAGRAM OF INTEGRATED RESEARCH APPROACH



This diagram shows the issues that are to be addressed in moving from:

1. Soils to crops

- Soil nutrients in relation to crops
- Suitable soil types, soil testing
- Fertilizer use and rates, soil and water conservation.

2. Crops to soils

- Through cultivation, clearing, burning, destruction of soil structure; improper cultivation methods
- Alley cropping, agroforestry (Revegetate), use of nitrogen fixing crops, rotations, inter-cropping, erosion control and manures and other organic matter.

3. Crops to animals
(silvi-pasture)

- Crop residues for feeding and beddings
- Grains (surplus) for feeding
- Forage crops/selection and screening for spieces
- Toxicity and its related problem
- Quality and nutritional value.

4. Animals to crops

- use of animal power in ploughing, ridging, weeding and other cultivation practices
- farm yard manure, farm produce, harvesting, threshing and irrigation.

5. Animals to soils

- Reduce damage done to soil by heavy implements
- Conservation of soil and water and farm yard manure
- Reduce over-grazing and burning for fresh vegetation by good husbandry practices.

6. Soils to animals

- Support pature/forage growth
- Range management sites for watering points
- Swampy/dry areas
- Animals Diseases/pests.

With this plan of integration, researchers' programmes should go further in trying to see how research findings can be made available to the farmer through a very strong research and extension set up.

Discussion

E. DERY

What would you say about mounding in terms of soil fertility in the Upper West Region?

A.Z. SALIFU

(i) Mounding is done on shallow soils to support plant growth
(ii) Mounding reduces weeds problem
(iii) It reduces drainage problems in poorly drained soils. The crop grows on the mound and the water flows at the bottom of the mound serving as furrow irrigation.

ANIMAL HUSBANDRY PRACTICES AND THEIR EFFECT ON THE FARMING SYSTEMS OF THE SAVANNA ZONE

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Pong-Tamale, Northern Region, GHANA)

Summary

Livestock rearing and crop farming in the savanna zone of Ghana have been practised as if they are not inter-related. The systems of rearing livestock and crop farming in themselves have their merits and demerits.

With the rapidly increasing human population which is resulting in increasing pressure on available arable and grazing lands and with the decreasing fertility of the soils it is becoming increasingly important that appropriate agricultural technological packages be developed to ensure that livestock rearing and crop farming complement each other.

Mixed farming is suggested with the provision that the land tenure system in the area will change to allow ownership of land and that the use of by-products from field crops will be encouraged.

1. Introduction

The people of the savanna zone (Northern, Upper East and Upper West Regions) of Ghana have for a long time been associated with livestock. Thus, it is not an accident that the zone contains over 75% of Ghana's cattle population of 1,143,666 (1988) and a little over 36% of Ghana's small ruminant population of 4,160,166 (1988). However, the type of animal husbandry they practise has been described as traditional and the productivity is generally low.

The rapidly increasing human population has resulted in increasing pressure on arable land. Livestock numbers are also increasing though at a low rate. There is therefore an increasing competition between the human population for land for crop farming on one hand and the animals for grazing on the other hand. The activities of both the human and livestock populations are rapidly affecting the environment, the principal effect being soil degradation.

Within the savanna zone, crop farming has over decades been to a large extent separated from livestock rearing as if it is not the same farmers involved in both systems. We as planners, scientists, etc. have watched this situation continue as if nothing can be done about it. In any case is there really anything that can be done?

This rather ecologically, economically and agronomically dangerous and unsound agricultural system poses a very serious threat to the very existence of the farmer and unless steps are taken to ensure the integration of livestock raising and crop farming, in the near future we may be faced with a problem too enormous and complicated to handle.

The question to be asked however is: "Is it the crop-farming systems which influence the animal husbandry practices or vice versa?" Even though this paper makes no assumptions with regards to this question, an attempt is made to suggest improvements in the animal husbandry practices which hopefully may facilitate the improvement in the overall farming systems in the savanna zone.

2. Systems of agriculture with which livestock are associated

Livestock may be associated with the following major tropical agricultural systems (Payne, 1976):

1. Migratory shifting cultivation.
2. Sedentary shifting cultivation.
3. Sedentary subsistence rain fed and/or irrigated cultivation.
4. Regulated lay farming.
5. Perennial crop cultivation.
6. Nomadic herding.
7. Transhumance or Semi-nomadic herding.
8. Commercial ranching.

In the savanna zone of Ghana, sedentary subsistence rainfed and/or irrigated cultivation is virtually the most common system of agriculture. Albeit, there are still a few areas where sedentary shifting cultivation may be practised but there are obvious indications that in the short term, the pressure of human population will lead to a growing demand for land leading to shorter fallow periods which will eventually give way to sedentary subsistence rainfed cultivation.

3. Livestock in the northern sector of Ghana

In every village of the northern part of Ghana one will find livestock - cattle, sheep and goats. The livestocks are of multiple value. They do not merely stand for, and so are not always readily translatable into a money value but can represent variable combinations of power, prestige, pre-requisites of adulthood, marriage or parenthood or means of establishing social relationships. In other words, livestock and especially cattle have several roles to play in the societies of Northern Ghana. These include spiritual roles, payment of bride price and fines.

People wish to see the numbers of their animals increase not only because of their experience with epizootic diseases but also because it enhances their prestige. Under the traditional system in the north, land is communally owned and therefore no one derives pride of ownership from a piece of land which he occupies. Cattle are recognised as an alternative form of wealth to land.

Livestock also has economic roles in all the societies in the north. Cattle are a stable form of currency less affected by inflation and devaluation.

The value of the animal in terms of young ones born also appreciates faster than money in the bank. This is particularly true because indigenous livestock are quite fertile even under modest levels of husbandry. As a rule an animal is not sold until its reproductive potential has been fully exploited. Cattle provide the cheapest and most dependable form of power in the rural areas.

4 Livestock and agriculture

4.1 The role of livestock in agriculture in the Savanna Zone

Having mentioned some of the roles livestock play in the rural society in the northern sector of Ghana, I would like to state emphatically that one of the greatest set backs in agricultural development in the north of Ghana has been the continued separation of livestock rearing from crop cultivation. Indeed if in talking about agricultural development in the area reference is being made to the over 90% of the population which is engaged in agriculture in the rural areas, then it is only sad to say that we cannot improve crop production without at the same time improve livestock production. The two are closely inter-related and inter-dependent.

Within the traditional livestock system, most of the live-stock is multipurpose especially cattle, providing a variety of outputs including draught power, milk, meat, hides and skins in addition to providing a source of capital to be drawn on as required particularly following crop failure.

Furthermore, manure from the large ruminants serves as fuel which can either be used in the home or sold and can also be used as fertilizer.

It is proper to mention that due to the low yields obtained from farms, accompanied by post-harvest losses, there are often sporadic food shortages at periods preceeding planting. The only option left for the farmer is to sell his sheep, goats or cattle to be able to purchase food for his family. Without the livestock which as mentioned earlier constitute the farmer's portable bank, many families in the area under consideration may perish.

Notwithstanding this reliance of the majority of farmers on livestock for their very survival it is significant to note that the attention given to livestock not only by the farmer but even policy makers and planners of agricultural projects in the area has very often been insignificant.

4.2 Animal husbandry practices and farming systems

A general feature of the livestock system in the savanna zone is that cattle are herded by contracted Fulanis who appear to have few, if any other interests in life apart from cattle and cattle keeping or children. The animals are either confined within kraals at night or tethered on the outskirts of villages. In some areas they are kept within the homestead.

Where cattle are tended by the Fulani, the cows are milked in the mornings and herded out of the kraals as late as 10 a.m. to areas where grazing is available and also to water. They are returned to the kraals sometimes as early as 3 p.m. and usually not later than 4.30 p.m. If one assumes that grazing areas and water are quite distant from the homesteads then one begins to appreciate how much time these cattle are actually allowed to graze during the day.

Most of the Fulanis have a knowledge of elementary breeding principles. They have very good memories and knowledge of parental relationship of the individual cattle under their control, even some have an excellent knowledge of the relative values of useful and harmful grasses, forage plants and the edible varieties of savanna shrubs and trees. They can readily recognise sickness and take elementary remedial measures. The Fulani is generally quiet and confident in his handling and controlling of the cattle individually and collectively.

The other method is to employ a number of small boys to manage village herds or parts of herds, usually with little advice or supervision from the adults. The cattle wander more or less around the villages, wherever there may be some forage. Their chief function is often merely to prevent the herds from entering crop farms.

Sheep and goats are usually not herded. During the farming season however, they are tethered around the homesteads and villages to prevent them from destroying crop farms.

The cattle in the savanna zone depend entirely on the available unimproved natural grazing. Apart from bullocks, very little if any supplementary feed is provided even when most of natural grazing has been destroyed by fire.

In discussing the animal husbandry practices as they relate to crop farming in the north it is necessary to differentiate between two types of farmlands. These are the compound farmlands and bush farmlands. Compund farmlands are those surrounding homesteads or villages. In most parts of the Northern Region where villages consist of clusters of houses, the coverage of farmlands is usually limited to a few meters away from the cluster of houses. In some parts of the Upper East Region where villages consist of homesteads, sometimes 100 or 200 meters apart, compound farmlands are much larger for each family. However, this situation is not expected to last very long as the human population grows and more houses are being built on compound farmlands. In areas where homesteads and compound farming is most common, the first problem is the access from the homestead to the grazing fields. They will obviously have to traverse not only their own compound farm but also those of neighbours. In fact in the Bolgatanga area, it is very common to see conflicts between farmers as a result.

While this situation is creating concern in the Upper East Region, in the Northern Region where pressure on land is not yet critical, during the rainy season when pastures are lush and one expects cattle, sheep and goats to be able to graze to the fill, these livestock are seriously restricted in their area of grazing because of the many bush farms. Hence the gain in live weight does not correspond to the abundance of feed.

Farmers will continue to rear their livestock and as long as livestock has socio-economic roles in their livelihood they will continue to aspire to increase their numbers.

Having settled for this inevitable future situation, I will now touch on some of the contributions livestock can make towards improving the farming systems in the savanna zone. Firstly is the provision of draught power (Panin, 1987), secondly the provision of manure and thirdly the sale of livestock to purchase farming inputs.

4.3 Future improvements in animal husbandry practices which may facilitate improvement in farming systems

One prescription that can be made to ensure that livestock rearing and crop farming complement each other is **Mixed Farming.**

In this context and in my view mixed farming would require that the farmer acquires the land and settles on it. There, he keeps his livestock and does his crop farming either using the hoe or bullock traction. All the droppings of his livestock will be on his land which he can plough into the soil to enrich it.

Where homesteads and compound farming assume greater prominence, there is the possibility of encouraging mixed farming. This will necessitate feeding of the livestock and with the abundance of by-products from field crops (rice straw, groundnut vine, cotton seed etc.) in the savanna zone this should not be a problem. These by-products, however, should be conserved and not allowed to burn. In addition water should be available to the livestock within the immediate vicinity of the farmland. Unproductive animals and male animals surplus to breeding should be culled.

5 Conclusion

An attempt has been made to critically look at the relationship between livestock raising and crop farming in the savanna zone of Ghana. The discussion is by no means complete considering the fact that farming systems are greatly influenced by a complexity of factors.

Nevertheless, if livestock should have a major role to play in improving farming systems in the north, then mixed farming where livestock can be used for traction and their faeces used as manure and where residues and by-products from the field crops can become available to the livestock as feed may in no small measure improve livestock productivity and also improve crop yields.

References

Panin, Kwame (1987) - Special Report No. 1. Hoe and Bullock farming systems in Northern Ghana. A comprehensive socio-economic analysis.

Payne, W.J.A. (1976) - In beef Cattle Production in developing countries. Edited by A.J. Smith. P 120.

Discussion

O.A. APULLAH

What are the efforts the Animal Health and Production Unit is making to educate farmers on bush burning?

A. FRIMPONG

Historically bush burning was practised by the people in the savanna zone so as to keep off wild animals and also for hunting purposes. Having done this for a very long period, bush burning appears now to be a part of the culture of the people and it is going to be very difficult to stop it. One can only suggest early burning or controlled burning. Education of farmers on bush burning should not be the job of only one department. Everybody must be involved in educating farmers on the harmful effects of bush fires.

F. A. MENSAH

What should be the appropriate time for grazing as early release results in endo-parasite infestation?

A. FRIMPONG

The best time for grazing is during the cool hours of the day since feed intake is reduced when ambient temperatures are high. In fact in nomadic societies, cattle are even grazed at night when ambient temperatures are low. I do not think grazing animals in cool hours of the day will necessarily result in an increase in their worm burden.

T. KIPO

COMMENT. Livestock should not be considered more important than land. Although communally owned, land is very important. This is reflected in the number of inter-tribal conflicts in the country.

A. FRIMPONG

I will like to disagree here because human nature by itself is such that more value is placed on what is owned by the individual. Since land continues to be communally owned people in the savanna zone will continue to put more value on their livestock which they personally own than on land which they do not own.

IMPROVING FARMING SYSTEMS IN THE SAVANNA ZONE OF GHANA: THE AGRICULTURAL EXTENSION FACTOR

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Introduction

Farming systems approach to agricultural technology development or Farming Systems Development (FSD) is important because of the bottom up approach to the development of technology. A farming system is the result of a complex interaction among a number of interdependent components. To achieve it, an individual farmer allocates certain quantities and qualities of the four factors of production - land, labour, capital and management - to which he has access, to three processes - crop, livestock and off-farm enterprise - in a manner which, within the knowledge he possesses, will maximize the attainment of the goal(s) he is striving for (Norman, 1978). Factors accounting for an observed farming system include technical and human elements.

The technical element is made up of physical and biological factors while the human element is represented by exogenous and endogenous factors. Exogenous factors (i.e. the social environment - e.g. community structures, external institutions and developmental agencies such as extension, credit etc. and norms and beliefs) are largely outside the control of the farmer and influence what the farmer will and or is able to do. Endogenous factors (resources, goals, attitudes) are under the control of the farmer who will ultimately decide on the farming system that will emerge, influenced and sometimes constrained by the technical element and exogenous factors (Fig. 1).

The assumption with the farming systems development approach is that technology which fits the needs of farmers, particularly small-scale farmers, is not available and needs to be generated locally. For extension personnel this is good news because they are provided with research results tailored to meet the needs and interest of the local farming conditions. Thus the diffusion of innovations is made easier.

Extension's role

The issue, however, is defining extension's role on case farms in the farming systems approach. It is axiomatic that an effective agricultural extension service is an essential component of agricultural development. This is because irrespective of the approach being adopted, extension, as a non-formal educational process has always played the vital role of facilitating the diffusion of agricultural innovations to

FIG. 1 HERE

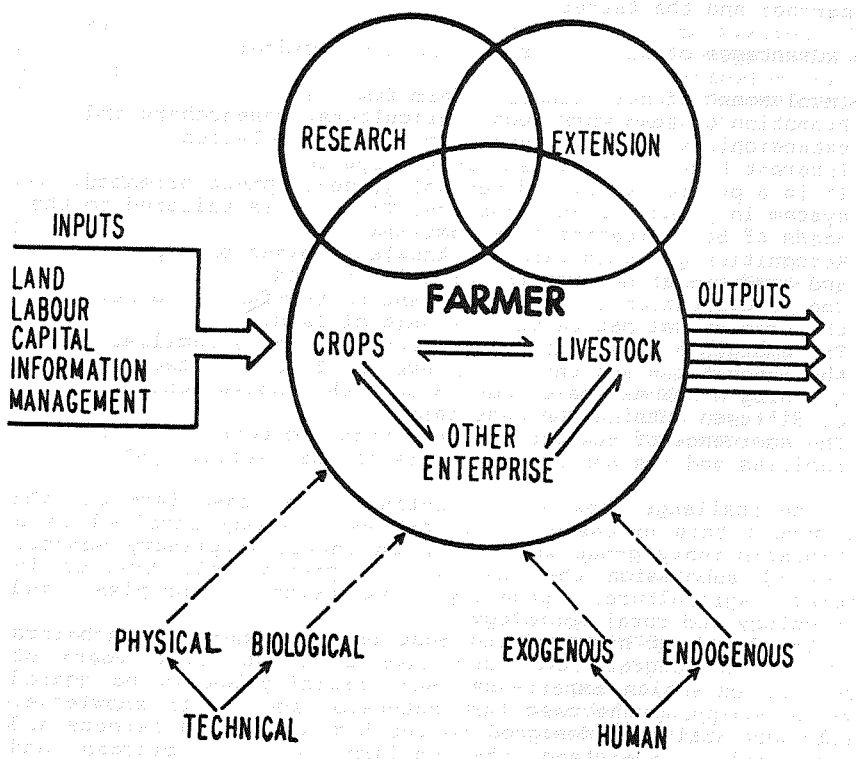

FIG. 1. EXTENSION IN THE FARMING SYSTEMS CYCLE

farmers and the extension worker should be brought into the picture during the exploratory survey stage in the development and testing of improved technology in trials situated on farmers' fields. Initially, the managerial input should be provided by the research worker but then, later by the researcher, agent and farmer and finally by the farmer himself or herself - farmer's testing. It is submitted here that for both efficiency and effectiveness of the farming systems approach and subsequent diffusion of the innovations outside case farms, the extension agent should be brought into the picture right from the onset to form a viable link between the researcher and the farmer.

The advantages of such a F.S.D. approach include:

1. Involvement of participating farm families.
2. Promotion of team work among agricultural researchers and extensionists who have tended to work in isolation.
3. Inherent Linkage mechanisms in the system.
4. It is a participatory and technology development oriented system in principle and practice. Thus, it is tailored to the needs of participating farm families.
5. Recognition given to farmers' knowledge based on experience and traditional net return per unit of land.
6. Use of evaluation criteria relevant to the farmer rather than the traditional net return per unit of land.
7. The emergence of an extension agent thoroughly familiar with the innovations and the social system. This will facilitate training other extension agents once the innovations are to be diffused outside the case farms.
8. The emergence of researchers sensitized to both the farm families and the non-human factors of the farming system.

The challenge, however, is defining the "case farm agent". Who should this extension agent be? As somebody involved in a multidisciplinary group working in an interdisciplinary manner, it is my submission that he must be pretty well trained in general agriculture, pedagogy, extension principles and methodology and rural sociology.

The level of his training must be to either the bachelors or the first degree level and have at least three years of practical extension experience. Such training should be geared towards equipping the case farm extension agent with knowledge, skills and attitudes designed to let him understand farmers and their needs, understand the on-farm research process and procedures, and understand programme planning, implementation and evaluation.

This calibre of case farm agent must interface comfortably with the researcher and the farmer. He must understand the researcher and the researcher's methodology in order to communicate to the farmer and also he must possess a thorough understanding of the social system in order to relate well to the farmer and communicate his concerns to the researcher.

The development of case farm agents should follow good principles of personnel development encompassing recruitment, training, motivation, recognition and retention (Fig. 2).

Recommendations for development

Based on research, extension, agent motivation and personnel development, the following specific recommendations are proposed for the development of case-farm extension agents for interfacing with scientists and farmers in a farming systems approach towards the development of technology(ies).

Recruiting

Recommendations of recruiting include:

1. Recruit top quality people from existing extension agent pool after performance appraisal.
2. Recruit first degree holders with general agriculture background.
3. Recruit potential case farm agents at regional level making sure that candidates from the locality in question who are familiar with the social system are given preference. This will facilitate language and other cultural interactions.

Training

Recommendations for training include:

1. Training in general agriculture.
2. Training in on-farm research methodology.
3. Training in aspects of rural sociology relevant to agricultural development.
4. Training in agricultural extension principles.
5. Training in pedagogy and extension methodology.
6. Training in programme planning, implementation and evaluation.

It is suggested that training be carried out either at university, research stations or Ministry of Agriculture training centres or on selected case farms for on-farm research depending on aspects of training to be accomplished.

Fig. 2 HERE

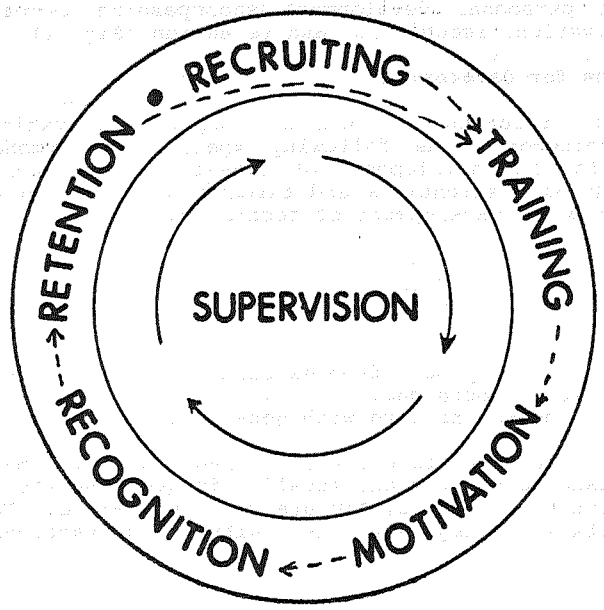

Fig.2 MODEL FOR AGRIC. EXTENSION PERSONNEL DEVELOPMENT

(MODIFIED AFTER KWARTENG ET AL 1988)

Motivation

Specific recommendations for motivation include:

1. Provision of training activities.
2. Provision of timely promotion to deserving agents.
3. Provision of good salaries.
4. Involvement of agents in decision-making.
5. Provision of adequate transportation.
6. Provision of good communication with units interacting with the agent.
7. Participation in conferences, workshops etc.
8. Provision of good supervision.

Recognition

Recommendations for recognition include:

1. Provision of certificates of merit (tangible recognition).
2. Provision of promotions.
3. Award of scholarships for higher studies.
4. Provision of informal verbal recognition, praise and encouragement by others involved in agriculture.

Supervision

Recommendations for supervision include:

1. Providing performance appraisal feedback.
2. Providing avenues for other evaluation (e.g. peer, farmer, researcher, etc.).
3. Providing a forum for discussing problems.
4. Providing constructive criticism from supervisors.

It is believed that such personnel development effort will contribute positively towards the development of effective and efficient on-farm research extension personnel or case farm agents.

References

El-Zoobi, A. M. (1987). Contemporary Agricultural Extension Systems Experienced by FAO. Paper presented at the International Agricultural Centre (IAC) Wageningen, The Netherlands. F.A.O. (June)

Kwarteng, J. A. (1990). Motivation and Related Variables of Agricultural Extension Agents in the Western and Central Regions in Ghana. Paper Presented at the Maize and Cowpea Workshop of the Ghana Grains Development Project, Kumasi, Ghana. February 1990.

Norman, D. W. (1978). Farming Systems Research to Improve the Livelihood of Small Farmers. American Journal of Agric. Econ. Vol. 60, pp 813-818.

THE POTENTIAL OF AGROFORESTRY IN THE NORTHERN SAVANNA OF GHANA

S.J. Quashie-Sam

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Harrison (1989) in his book, "The Greening of Africa", wrote - "Agroforestry is not only the most promising approach to reforestation and the supply of fuelwood, it is also, in yield-booting forms like wind-breaks and alley cropping, the most hopeful avenue for intensifying African agriculture over the next five to ten years, increasing food production and reducing exposure to drought with few or no outside or imported inputs. Agroforestry is arguably the single most important discipline for the future of sustainable development in Africa".

World Food Prize laureate Dr. Swaminathan (1987) also wrote - "Restoring African tree cover is essential to the restoration of the hydrological cycle and to the recovery of agriculture. Widespread introduction and promotion of agroforestry can go a long way toward sustainable resource management and ecological and economic rehabilitation of Africa". These two quotations give several points in favour of the potential of agroforestry in the northern savanna.

Agroforestry is an age-old practice which in recent times has received a lot of attention and the science of agroforestry is therefore developing at a rapid rate. This has been possible because scientists of varied backgrounds have shown tremendous interest in the integration of trees in crops and/or farming systems. Thus agronomists and soil scientists have been interested in the role of trees and shrubs in farming systems with particular reference to soil fertility maintenance and erosion control in small scale farming systems. Livestock scientists have been interested in the importance of fodder from trees and shrubs both in rangeland and mixed farming practices. Foresters have been interested in making forest products available to local communities through non-conventional forestry practices like village, rural, social and other forms of forestry. Ecologists have exhibited great interest in stable ecosystems and the positive influence of trees has drawn a lot of attention; experts in environmental sciences have shown concern in the area of deforestation, among other things, and tree cultivation in dry areas in particular. They have called and continue to call for the protection of the remaining forests and for the introduction of more woody perennials into farming systems.

The list of specialists of varied backgrounds showing interest in the integration of trees in farming systems cannot be exhausted. Such scientists as anthropologists, socio-economists, etc. have all contributed tremendously to the growth of agroforestry as a science.

Even though there is some occasional debate, agroforestry is now generally defined as "a collective name for landuse systems and practices where woody perennials (trees, shrubs, bamboos etc.) are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in spatial mixture or in temporal sequence. There must be both ecological and economic interactions between the woody and non-woody components (Lundgren 1982).

By definition, agroforestry is a near perfect system. Sustainable economic and ecological interactions of the components are expected. The views of Harrison (1989) and Swaminathan (1987) quoted earlier are very encouraging indeed and I must say I was pleased with the topic "The potential of agroforestry..." as it is positive. The organisers of this workshop must have made up their minds that agroforestry must have a potential in the northern savanna of Ghana.

In order to assess the potential of any technology a look at the problems or constraints the technology is supposed to address is a logical first step.

The Northern Savanna of Ghana which you are all familiar with is one of the most important agro-ecological zones in Ghana, especially in the light of its potential, economic and ecological rehabilitation. The problems of the zone are many. They stem from a very vicious cycle which is common to the traditional shifting cultivation of most tropical countries. The traditional farming systems have made use of agroforestry principles and particularly the bush fallow component had been very important. With the increase in population, and the fragmentation of land through traditional inheritance, these traditional systems are no longer sustainable.

The systems have become problem systems because many farmers are practising it without "shifting". The fallow period has been shortened drastically, and in some areas there is virtually no fallow. Consequently the cropping period has also been shortened with its attendant reduction in yields. Many scientists have attributed this to the indiscriminate reduction in the tree component. Soil erosion resulting from improper land management causes several ramifications in the constraints of this area. The problems of the northern savanna agro-ecological zone is comparable to what is said about agriculture in Rwanda. "Rwandan agriculture is now caught in the process of continuous degradation, over-population goes hand in hand with over-cropping of fertile lands, the use of more fragile fringe areas around arable lands, shrinking of pasture lands, over-grazing, uncontrolled deforestation, etc., labour productivity is decreasing. Mal-nourished crops grown on impoverished soils, moreover become disease susceptible. The result is the deterioration of plant canopy, which includes decreasing biological and genetic diversity, decreasing soil fertility, and soil losses due to erosion" (ISNAR, 1982). This situation is common to many of the areas that shifting cultivation has had its toll. These problems are presented in a diagram showing a landuse problem chain (Figure 1).

As soon as farmers are forced to more marginal lands or to reduce fallow periods, traditional farming systems are no longer appropriate. This is the situation we are approaching in the

Northern Savanna. We are therefore experiencing loss of soil fertility and a decline in yield, soil erosion and loss of cultivable land, hydrological degradation and the changes in the river regimes and sediment load leading to flooding etc., indiscriminate forest clearance which enhances many of the problems listed, pasture degradation which is an important part of the rural economy and fuelwood shortages.

If unchecked, the long term effect of this problem cycle would be so devastating that, poverty would be increased and the natural resource base would be irreversibly destroyed through rapid decline.

The potential for agroforestry in the northern savanna lies in the contributions agroforestry could make towards arresting the environmental decline, and improving sustaining land productivity. This would be done through:

- Intensification of food crop reproduction
- Conservation of natural resources; and
- The diversification of production so other products other than food could be obtained from the same piece of land.

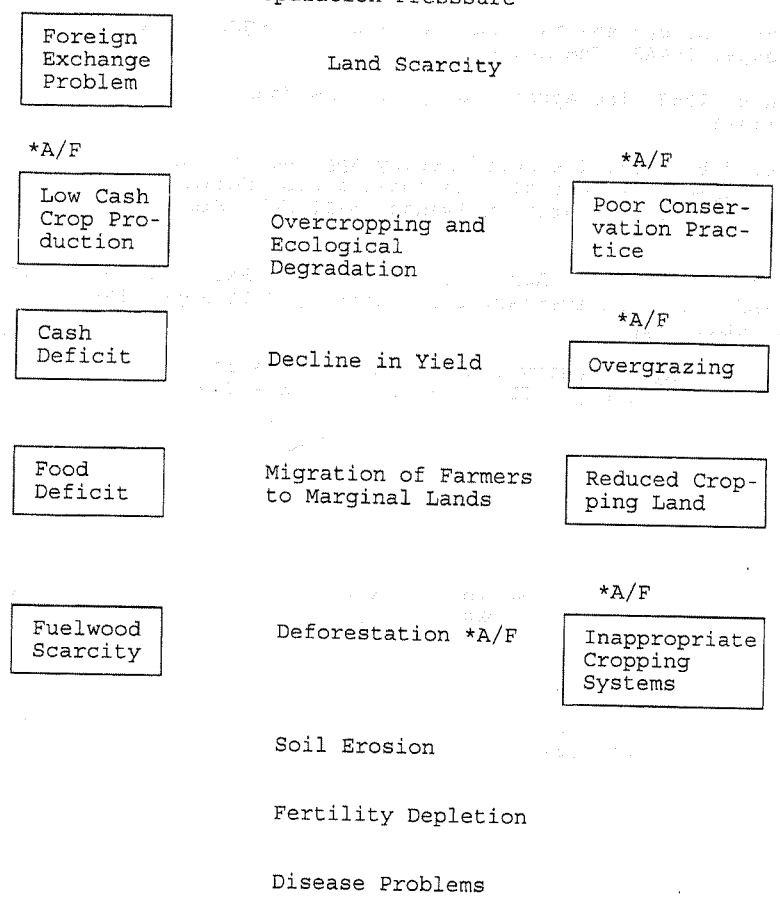
The following technologies may play significant roles: systems of trees on cropland, boundary planting, trees on erosion control structures, live fences, fodder bands, and hedgerow intercropping. Windbreaks, shelterbelts, and trees on rangelands are also important. Home gardens may also have some potential in the area.

I would like you to see short video productions by IDRC and ICRAF which would elaborate on the potential of these agroforestry interventions.

In discussing the potential of agroforestry interventions, we are faced with a spectrum of knowledge and ideas; some of these are clearly tested and proven, others logical but need to be tested. We are a gathering of experts and institutions that are looking at farming systems, many times at components of these systems, and can show how to maximise production of the individual components but lack of understanding and expertise (especially when trees are involved) on how to optimise all the various components to the advantage of the farmer.

A detailed understanding of which technologies would work, or would be adopted is lacking. Many of the technologies have to be tested in this agro-ecological zone with regards to the specific micro-environment and socio-economic setting. There is a positive potential for agroforestry to help arrest the environmental decline of the northern savanna but there is an urgent need for a major programme of agroforestry research into the potential technologies.

FIG. 1 LANDUSE PROBLEMS CHAIN AND AGROFORESTRY INTERVENTION POINTS



*A/F - Potential agroforestry solutions.
(Adapted from Raintree, 1983)

References

Harrison, P. 1989. The greening of Africa: Breaking through in the battle for land and food. Paladin. 380pp.

ISNAR 1982. Le systeme National de Recherche Agricole au Rwanda. ISNAR, The Hague.

Lundgren B. 1982. The Agroforestry Systems Journal 1 (1):3-6

Raintree, J.B. 1983. The Agroforestry approach to land development, Potentials and constraints. Seminar on Agricultural Research in Rwanda. 5-12 Feb. Kigali, Rwanda.

Swaminathan, M.S. 1987. Agroforestry in Asia. Paper presented at ICRAF's 10th anniversary celebrations, 7-11 Sept. 1987, Nairobi. 39pp.

Video films - Agroforestry Today - ICRAF- This is ICRAF - Trees of Plenty - IDRC- Trees of Hope - IDRC.

SESSION 5

CHAIRMAN: PROF. D.K. ACQUAYE, UNIVERSITY OF GHANA, LEGON

RAPORTEUR: MR. CECIL OSEI NYANKPALA AGRICULTURAL EXPERIMENT STATION

PANEL DISCUSSION

THEME: PRESERVATION OF THE ENVIRONMENT UNDER INCREASED AGRICULTURAL PRODUCTIVITY IN THE SAVANNA ZONE.

MEMBERS:	Prof. D.K.Acquaye	- University of Ghana, Legon (CHAIRMAN)
	Mr. H. Mercer-Quarshie	- Co-Project Manager, NAES
	Mr. S.Y. Anane	- Reg. Director MoA
	Mr. S.A. Gumah	- Private Farmer
	Dr. S.A. Botchey	- IFAD/SRDP Programme Director
	Mr. E.A. Addison	- Director CRI
	Dr. H. Rudat	- Project Manager, NAES
	Mr. J.K. Wumnaya	- Director MoA, Upper East Region
	Mr. M.K. Ansah	- Director of Extension Services, MoA, Northern Region

CHAIRMAN'S OPENING REMARKS:

The objective of this panel discussion is to summarise all discussions on the individual papers, highlight the constraints to increased productivity without deleterious effects on the environment and then make recommendations. We will proceed as follows: a member of the panel will give a brief preview of the topic, followed by a discussion among the panelists and a general discussion involving the floor.

ITEM 1. CLIMATIC CONSTRAINTS - EFFECTS

Preview by H. Rudat.

We are all aware that man is probably the main contributor to the rapid changes of our climatical conditions south of the Sahara desert and worldwide. This may result in the disruption of the normal rainfall pattern and influences in various ways, mostly negatively, agriculture, animal husbandry, sweet water fishery, etc. On the other hand the known and aggravating "green house effect" resulting from exessive emissions of carbon dioxide, other gases and heavy metals from industries and trafic in industralised countries, can in tropical/subtropical areas be attributed to extensive burning of the natural vegetation and cultivated land (bush fires). In consequence changes in the temperature regimes have been noticed which might lead on one side to excessive rainfall and on the other side to increase droughts around the globe. Slowly but surely the earth is loosing its natural buffer system if we continue the present rates of destruction of our natural environment. Global agriculture will suffer substantially and might be the first looser in a long chain of loosers - mankind.

Chairman:

Then, can we say that with our long dry season, higher rainfall will be an advantage since we only have to put in place the necessary facilities for water harvest?

S.A. Boakye:

With the shallow nature of our soils higher than normal rainfall within the same period could lead to severe erosion problems.

U.E.D:

We have once tried bonding for water harvest but the local farmers always come back to remove them. I suggest that the land planning committee which used to exist should be revived.

Chairman:

Can we have any comments from the floor?

K.A. Haizel:

The rapid population increase makes the conservation of natural resources a very difficult problem. We are only trying to delay dooms day with these measures that are being proposed. As long as biological beings exist the natural resources will decline. I think we have very little chance in the fight against the depletion of the earth's resources.

Chairman:

But we have to try at least to conserve something to prolong our stay on this earth. What measures can be taken to ensure this?

S. Twumasi-Afriyie:

On the international front, a lot of efforts are being made to arrest some to the effects which have been seen to set in. Here we can start by refraining from practices that have resulted from adverse situations in the developed countries.

H. Rudat:

As I mentioned earlier, bush burning particularly in the evergreen tropical rain forests contributes a lot to the total carbon dioxide produced in tropical/subtropical areas which is causing present global climatical developments.

H. Baur:

Our main effort or drive should be at preventing desertification in Northern Ghana. If we take a global perspective, solutions found might not be appropriate.

K.A. Haizel:

We have to promote tree planting as a culture. The cutting of trees in our villages for fuel wood and charcoal is almost a culture. Therefore tree planting should be promoted likewise.

G. Bolfrey:

We should improvise for the use of the coalpot since certain traditional foods are always prepared using the coalpot.

S.A. Gumah:

Prohibiting burning on farmlands would lead to uncontrolled burning. Therefore, we must accept and introduce controlled burning. Secondly, the dimensions of a culture of tree planting is very wide particularly with reference to the absence of controlled grazing in this area.

H. Mercer-Quarshie:

We have to acknowledge that since the so called 'green house effect' is global we cannot work in isolation. Secondly, since the total population and the population growth rate in Northern Ghana is very high and which will lead to increasing requirement for arable land and fuel wood, we should also direct a substantive part of our efforts to control the population growth.
Again since we have heard during this workshop that irrigation can increase yields ten fold, this can be a solution to feeding the increased population. Though we have to make our people aware of the disadvantages of the high population growth rate.

E.A. Addison:

The problem with large irrigation projects is, e.g. the lack of agronomic packages. How much water is to be applied and when. I want to say that there is a whole lot of data we need to generate from irrigation research before irrigation projects can succeed.

S.A. Botchey:

Another point is that previously the central government was solely involved with irrigation projects. Recently communities are being involved so that awareness about planting trees in the catchment areas can be easily brought home to them.

K. Setsoafia:

We are doing a similar thing at the Vea reservoir with the help of U.N.D.P. Though farmers are not very eager now we hope to get them gradually involved.

K.A Haizel:

A good survey to characterize our underground water system will be a basis for efficient water management planning and utilization.

Chairman:

We must admit that this will be good for the long term but in the interim we must make use of small dams which will involve the community and then use the opportunity to educate them on tree planting.

ITEM 2. AGRONOMIC CONSTRAINTS - LAND CLEARING

A. Effect of land clearing methods, cultivation practices and weed control.

Preview by K. Botwey (Coordinator, IFAD-SRDP.)

Land clearing in Northern Ghana has been regulated for some time now. During the rice boom of the 1970's a lot of trees were destroyed. Most machinery used for land clearing are heavy and lead to soil compaction. Blades of bulldozers also scrap off most of the top soil of these shallow soils.
Deep disc ploughing practiced by many large scale farmers cause more harm than good.
Contour ploughing could be one solution to minimise erosion but very few farmers practice it.
Zero tillage has its own advantages and disadvantages. Despite the reduced work involved, it increases run off and decomposition of organic residue is hampered.
Weed control also has its own problems. Again the use of herbicides sometimes leave the soil bare before planting and then exposing the soil to erosion hazards.
There is the need for an integrated approach to land clearing and weed control.

S.Y. Anane:

Tractor "operators" in the region are indeed tractor drivers. This is one of the main problems of improper ploughing. In-service training on a larger scale should be looked at.

S. Twumasi-AFRIYIE:

We should still look carefully at zero tillage. This has many advantages especially for most of the small-holder farmers in this area.

J.J. Afuakwa:

Zero tillage really has a lot of advantages but for the continued use of herbicides, coupled with the illiterate level we have here the pollution of the environment will be quite rapid. In my presentation the yields from zero tillage were quite low. I am made to understand that the advantages are evident after 2 or more seasons.

M. Bonsu:

I agree with Dr. Afuakwa that advantages are evident only after two seasons or more and additional costs are involved compared with conventional tillage. The use of planters and abuse of chemical use are the main disadvantages on such a system. Conservation tillage rather should be looked at carefully.

Quarshie-Sam:

I don't think we have got any package for any agroecological zone for the farmer. Minimum tillage should rather be considered and will be more suitable since farmers are already practicing a form of minimum tillage with the hoe and cutlass.

H. Mercer-Quarshie:

Since herbicides have also been found not to be cost effective, minimum tillage is preferable in these circumstances.

M. Bonsu:

Even with the hoe some amount of sheet erosion occurs.

K.A. Haizel:

The use of bullocks could be stretched. This can even give room for the effective use of farm yard manure. The extension agents can help a lot in this.

B: Effect of control of plant pathogens and pest on environment

Preview by E.A. Addison

Pathogens and pest contribute a lot to crop failure and yield loss. Pathogens in the seed are the most important and most often looked over. There is also the field and storage pathogens and pest.
The life cycles of most of these pathogens and pests have been studied and their effect on the productivity of the respective crops have been documented. However, control measures recommended are varied; from chemical to biological control, including bio-pesticides.
Some of the control measures recommended also include physical means. Agronomic practices for example mixed cropping, time of planting to escape pest attack, bio pesticides like the neem and chemical control including dusting, aerosol spray and seed treatment are possible measures.
Some of these measures obviously have no adverse effect on the environment. But chemical control should be discouraged as much as possible to keep a safe and balanced environment. So I am of the opinion that we look at other efficient methods of pest and disease control other than chemical control.

Chairman:

We can start the discussion by highlighting a few of the major pests and diseases of these crops so as to know exactly where we are with respect to their control.

H. Mercer-Quarshie:

On rice, blast is one of the most important diseases. Varieties that are said to be resistant or tolerant begin to show symptoms after some few years. Local sorghum varieties have a lot of diseases and pests but they are not considered economically important. However, with the improved varieties, head bugs, midge, head mould and shoot fly are economically damaging. Smuts are also present but not so serious. Millet is mainly attacked by downy mildew. For the legumes, groundnut is mainly attacked by Cercospora and occasional insects but cowpea is attacked by a host of economically important insects. Striga is also a very important pest for all the cereals and on cowpea. Birds can also be taken into consideration.

Chairman:

We can see we have a lot of plant protection to do, taking these insects into consideration, but can we be sure that as we try to solve them, more are not introduced from outside. How effective is the Plant Quarantine Service?

E. Addison:

We have had the Quarantine service for a long time. However the service is rather weak and needs strengthening. But one must point out that not all diseases and pests are controlled this way.

G. Iddi:

I feel the present recommended chemical control regime for cowpea is rather high especially in terms of frequency of spraying. Have we been able to establish an economic threshold where a formulated mixture can cater for most of the pests.

A.B. Salifu:

The important pests on cowpea are the flower thrips, the pod borer and the pod sucking bugs and may be the aphids. The spraying regime recommended is based on the fact that these insects come at different stages of growth. At present the small scale farmer will find it difficult to identify the economic threshold even if there is any. We are currently in the process of developing one.

K.A. Haizel:

Mr. Addison mentioned the importance of disease and pest free seed for cultivation. I wish to mention here that the seed production and distribution system is dead and needs to be resuscitated. When resistant genotypes are developed and accepted we will eventually be faced with a poor seed quality control and distribution system.

ITEM 3: SOCIO ECONOMIC CONSTRAINTS - EFFECTS OF POPULATION ON PRODUCTION AND ENVIRONMENT

Preview by UERD

The population growth rate in the Northern Region is about 3.4%, the highest in the country. Together with that of the UER (2.5%) and UWR (2.5%) we have an average of 2.8%. The consequences of such a population growth rate in terms of deforestation and soil degradation is enormous. Despite the high population growth rate, labour shortage during the critical periods of the cropping season is common. This is the result of the erratic beginning of the rain fall and the short duration of the season. The result is a heavy schedule of planting and weeding periods. One possible solution is mechanization but it has its own problems and limits. Education of the rural folks, particularly in the area of adult literacy programmes can be also a viable solution. I would also like to say that entrenching the decentralization process particularly of infrastructure to keep the youth at home is necessary.

S.Y. Anane:

Since the reward for labour in the region is mostly in kind, the farmer ends up with less than 50% of the harvest. So we hope that most of the simple hand implements we have seen displayed will solve this problem when they are adopted by farmers.

Quarshie-Sam:

If the avenues for generating off-farm income are many in the region, it can also stop the southern flow of labour hands in the off season where they sometimes return late in the season.

S. Gumah:

I agree with Dr. Quarshie-Sam. Even farmers at present will need more off-farm income to pay for the labour either in kind as in communal farming or otherwise in cash.

A.B. Salifu:

One solution will be a sustained education and literacy campaign, particularly, what used to be done by the mobile units of the ministry of information. This can encompass family planning and agricultural issues. The development of entertainment aspects will also help to minimise the labour migration.

Chairman:

It is quite clear from the discussion that increased productivity is linked with the literacy rate in the area.

ITEM 4: INFRASTRUCTURE CONSTRAINTS ON PRODUCTION

(1) Agricultural credit
(2) Road network
(3) Transportation system
(4) Marketing

Preview by S. Gumah:

For a long time now farmers' involvement in policy planning has been very minimal without encountering the repercussions of such a situation here. We must agree that the situation needs to be rectified.
Credit facilities are almost always beyond the reach of the farmer. We expect that the group with the best chance to succeed in a farming venture are the university agricultural graduates. But because there is no capital base, no access to credit and the high interest rate charged on loans, they are those who seldom take on farming as a business.

The marketing situation presently is nothing farmers can be happy about. The role of middlemen which many policy makers decry is rather useful so far as the farmer is concerned, since produce disposal is a big problem for the farmer.

Chairman:

What are the bottlenecks with the present credit system and what can be done to improve it?

H. Baur:

One problem is that the banks will continue to demand collaterals from the small scale farmer in order to guarantee their operations. Again they will have to raise interest rates in order to make profit from the small amounts involved with small scale farmers. The Government will find it difficult to intervene with these issues.

S.A. Botchey:

A possible solution to small scale credit is the establishment of rural banks. With its large population and agricultural potential the Northern Region does not have a single rural bank. This is an area the government can intervene.

Chairman:

The system used by Global 2000 has received a lot of commendation. How can such a system be extended to all farmers?

S.Y. Anane:

Initially there was prompt repayment of loans by the farmers, but as the programme expanded to include more farmers, a large percentage defaulted in repayment. Since payment is in kind those who pay sometimes also give us the worst part of their produce.

UERD:

In the Upper East Region, we face the same problem. I have to mention that we also have a problem with the disposal of produce collected. We resorted to giving it to our own workers on credit and deduct the money at source. A policy encouraging and rewarding private investment in credit and/or marketing will be most welcome.

S.A. Botchey:

The banks can play a big role in this since they have large capital. Some banks started this policy some time ago but we see very little of them in terms of produce purchasing, warehousing and disposal now. Probably they can also give credit to individuals to undertake such ventures.

Chairman:

Can the present road network facilitate an improved market system?

A.B. Salifu:

The main network that links the three regions are in a deplorable condition. One would wish to know whether they are under contract or not but if funds are made available we could tackle the main roads first.

S.Y. Anane:

The Highways and Feeder Roads are responsible for the different networks and therefore both can be tackled at the same time.

ITEM 5: CONSTRAINTS ON AGRICULTURAL RESEARCH

Preview by H. Mercer-Quarshie

Northern Ghana has always been said to possess the potential to feed the nation. The progress of research has been very slow to reach the present stage. From 1947 to 1980, there was only one scientist taking all the crops in the mandate zone. Now we have about 30 researchers at NAES. There are now other Agencies and Projects like the IFAD/ SRDP, Ministry of Agriculture, Cotton Company, Animal Husbandry who are undertaking adaptive trials.
In terms of staff development we are in a better position now. Both middle level and technical staff have been and are being trained.
We also have a relatively better equipment support but if GTZ could do more, we would be in a better position.
Other problems include accommodation for staff, which is really acute and office space.

Agyen-Frempong:

Livestock research is very inadequate in the zone, particularly on pasture and fodder for cattle.

H. Mercer-Quarshie:

Since NAES has been mandated on certain crops we could cooperate with the Animal Research Institute (ARI) which has a station here to evolve a system of crops and livestock integration through research. It seems the ARI has problems with funding. So we recommend that the Government makes more funds available to the ARI because such a system can go a long way to solve the problem of overgrazing.

M.K. Ansah:

We have seen the second phase of the Project. Have we instituted any measures to ensure continuity should GTZ pull out?

H. Rudat:

The station has links with other international and regional institutions but a more intense cooperation on a wider basis with these institutions is needed. It is difficult for GTZ to withdraw from its international commitments since they are donors to these institution. For bilateral cooperation we are always limited by the problem of medium-term interactions. This is especially so with research which demands a long-term interaction.

Chairman:

This idea is laudable and should be realised as fast as possible.

ITEM 6: CONSTRAINTS WITH TECHNOLOGY TRANSFER

Preview by M.K. Ansah:

The Extension Unit is in a better position than previously, but we can do better if the present work conditions are improved.
Presently the extensionist to farmer ratio is about 1:2000 and on the frontline it can be as high as 1:3000 which is too much. We are aiming at 1:600 which is recommended. Another basic problem is mobility. The region has six vehicles, 3 on the IFAD project, 2 from GGAEP and 1 from MoA. There are thirty-six (36) zonal coordinators but only 13 motor-bikes. Also we have 350 Technical Officers and Assistants out of which only five percent have bicycles. The rate at which the problem is being tackled is too slow.
Motivation is very low. The rate at which promotion of officers are effected is poor. Remuneration levels are among the lowest in the profession.
Presently the only good linkage is between the Ministry of Agriculture and Crop Research Institute. Planning sessions are

organised regularly to formulate both research and extension programmes.
In-Service training is also regular as we see now in the Northern Region. The funding of these activities are rather inadequate.

There were no discussions on the above preview.

List of Participants

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