Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems in the Nile Delta

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Abstract

The principal animal production system in Egypt is the mixed crop-livestock production systems with a semi-intensive/semi-commercial orientation. The development strategies emphasized in this study contribute to the development and implementation of improved technologies.

The role and place of the livestock sector and its contribution to the national economy, as well as the development of external trade in milk and dairy products in the past 10 years were studied. The potential for dairy improvement is discussed and it is concluded that rapid population growth along with social and economic changes will further increase the demand for animal products. The traditional mixed farming systems were studied in detail. As part of these studies on-farm and on-station experiments on animal nutrition and feed utilisation were conducted. Additionally a computerised model of the mixed crop-dairy farming systems was developed to help decision-makers at farm level to obtain an optimal cropping plan and feeding system with maximum income.

The farm management information system was developed in the context of a mixed farming system in the northern part of Egypt. An identification and description of the management practices of both crop and dairy sub-systems resulted in a better understanding of the dairy farming systems and established the boundaries of the components that are used as the base for modelling the whole farming system. The constraints of the systems were also identified with special attention for feeds and feeding. Finally, this information was used to design and perform nutritional studies, which along with other information was was used to develop a decision support system for crop-dairy mixed farms.

One hundred and fifty five samples of maize silages made on-farm were taken to be nutritionally chracterised through visual inspection as well as on the basis of chemical composition. Good quality silages were obtained, indicating adequate preservation for all silages. The highest qualities corresponded to whole-plant maize (without removing ears), ensiled at an average age of 108 days, after 17 days of fermentation, and, up to a 45 days off-take feeding period (after opening of the silo). Variety and type of chopper used in this study, had no significant effect on silage quality. The final conclusion is that, small farmers easily adopted silage-making as an intervention as indicated by the quality of maize silage produced on-farm.

The quality of four feedstuffs: berseem (Trifolium alexandrinum), rice straw, a concentrate mixture and maize silage were investigated in two direct and three indirect metabolism trials with sheep. Under the conditions prevailing in Egypt, the fermentation process of maize silage reached an acceptable range (indicated by the fermentation products) after 16 days of ensiling. Maize silage had neither negative nor positive effects when fed with berseem. Feeding berseem with maize silage increased total DM intake and improved the energy/protein ratio (64%TDN and 12% CP) which would allow a medium level of milk production.

Eleven different combinations (scenarios) of the four feedstuffs were designed to assess the nutritional feasibility of 9 milk production levels. The scenarios aimed to satisfy the nutritional constraints and to minimize the feeding costs of the 9 milk production levels. Sensitivity analyses of the effects of changes in milk price, land rental and labor wages on the margin over feeding costs were performed.

With regard to the acceptability of maize silage by farmers, the study demonstrated the easy introduction of maize silage, the farmers awareness and the role of extension, the response to other new technologies with maize silage, the farmer's point of view and finally, the constraints of making maize silage in the study area.

The financial analysis showed that feed mixtures with maize silage would reduce feed costs compared with mixtures without maize silage. This conclusion not only holds at present price levels for land rental and labor, but also for prices that are till 100% above present levels.

Farmers in the project area have quickly recognized the advantage of adding maize silage to the diet of their dairy animals. Their observations focus on higher production levels and lower production costs, which is in line with the step-wise analysis of nutritional and financial aspects by the researchers.

Maize silage was well introduced by the extension staff and widely adopted once farmers had recognised its advantages.

Key words: farming systems, dairy farming, Nile Delta, maize silage, farm modelling, economic and nutritional evaluation

Contents

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Wageningen, May 2000

Propositions

1 Farmers are generally aiming at maximizing the utilization of their resources by pursuing a set of multiple objectives, not only including economics but also social, political and ecological values (this thesis).

2 New technologies can easily be rejected for reasons of unknown risks or expected uneconomic performance or inappropriateness to their resource availability (this thesis).

3 The adoption of a new technology in rural areas is a perfect indicator of a relevant technology design (this thesis).

4 A decision-making process based on field observations/experiments and farmer participation often leads to adequate mutual understanding, a prerequisite for the collection of appropriate data needed to optimize acceptable farm plans (this thesis).

5 The mentality of nations is the key for development and civilization.

6 Farmers all over the world do not do different things, they do things differently.

7 The best way to avoid critical conflicts between nations, cultures, civilizations or religions is to respect each other's values and traditions.

8 Democracy and human rights have no meaning with no education or an empty stomach.

9 Globalization is a hidden access to the third world resources and market.

10 Applying the sustainability concept will lead to a more unequal welfare between nations.

11 The lifestyle of a human results from all environmental events with which he or she is confronted since birth.

Propositions associated with the Ph.D. Thesis of Ahmed Tabana:

Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems in the Nile Delta.

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Chapter 1

Introduction, Background of the Study and Research Formulation

Introduction

Dairy enterprises represent only one component of animal production, which is in turn an integral part of agricultural production. Thus it can be best developed as part of an integrated approach to the total sector. Animals will compete with other enterprises for labor and perhaps for land, but it may parallelly benefit from other agricultural developments (e.g., increased crop production giving rise to additional edible by-products). Also, it can offer additional opportunities for income generation through local processing, which can in turn stimulate further technological development and employment in the area.

The principal animal production system in Egypt is the mixed crop-livestock production systems with a semi-intensive/semi-commercial orientation. The development strategies should emphasize actions that support development and implementation of improved technologies and the use of more production inputs. High priority needs to to be given to the development, through farming systems research, design and implementation of new technologies to enhance the productivity of mixed crop-livestock systems with different cropping patterns and production practices. Improved technologies may include improved varieties of food and feed crops, forages, and legumes; improved genetic stocks of indigenous buffaloes, sheep and goats; and improved crop and livestock management systems. Improved strategies for technology transfer and the establishment of more effective extension strategies are needed.

Development strategies that aim at increasing the productivity of a specific system must carefully consider the stage of development of the target area/group in relation to the nature of crop-livestock interactions, availability of specific technologies to improve productivity, availability and costs of inputs. The specific technology that will eventually be required to reach the optimum level of resource use still must be developed. Excellent possibilities exist for increasing production of milk through expanded use of improved technology and inputs. This requires that the traditional mixed farming systems are studied in detail, on-farm and/or on-station experiments on animal nutrition and feed utilisation are conducted, and models are developed that can help the different levels of decision-makers.

To provide appropriate management decision support to the farmer, the whole farm enterprise should be modelled. Such models should be based on analysis of the mixed farming system, taking into account the interactions among the household, crop and livestock subsystems. Model development can generally be based on data collected through monitoring programs, observations and discussions with farmers on their practices. The samples of farms to be selected should cover a range of management practices, thus enabling the use of comparative analysis methods to support the modelling process.

Background of the study

Analysis of large ruminant production in Egypt reveals a general feed shortage between the summer and winter cultivation seasons. This is primarily due to shortage of land to provide forage crops all year round. In addition, management limitations on most of the small and medium scale mixed crop/livestock farms result in resources being allocated sub-optimally.

Both, the quantity and quality of the feed play an important role in dairy production. In Egypt this is especially true, as the animals' demand for nutrients is high and the energy content of the most commonly available forage, clover (*Trifolium alexandrinum),* is low. Increasing the quantity of concentrates fed at this time, should result in higher availability of energy. Using the services of a feed mill which has facilities to formulate least cost rations, is a theoretical option. However, given the large variations in the quality and availability of raw materials, production of concentrate feeds of a consistent and stable nutritional quality is very difficult. While low quality roughage from crop by-products is available, the low digestibility of these materials limits their use as a source of energy, particularly for milking cows. The use of conserved forages does, however, offer some opportunities for overcoming the problem.

The most common conserved forage crop used by small farmers in Egypt is berseem hay. This is fed mainly during summer. Supplies are normally inadequate to cover the transition period from summer to winter, when the green feed maize (darawa) is finished and the new season's berseem is either not available or is of low nutritive value due to its early stage of growth.

Many options have been proposed for small farmers to overcome the feed shortage, including "new" forage crops, chemical treatment of roughages and forage conservation. These have met with varying degrees of success. Maize silage, which has in recent years been widely adopted on large-scale dairy farms in Egypt, has also been promoted with small farmers in a limited number of areas. The potential benefits as indicated by on-station experiments, and the initial positive on-farm response to the technology, suggest that it could be adopted more widely.

Small farms in Egypt are characterised by relatively complex production systems, often involving cash crops and livestock along with considerable home consumption. The introduction of innovations in one area of production will therefore normally have direct and indirect implications for other parts of the production system, farm income and household food security.

The eventual success of "new" technology will be determined by the farmers response in relation to its resource requirements, impact on profitability and risk. This response is, however, a long-term process, especially as farmers are not in a position to judge these issues in advance, particularly in terms of the production response to new feeds or feed combinations. Therefore, in the early stages of development, considerable benefit may be achieved by undertaking more analyses of the feed, its interaction with other components of the diet and its potential impact on cropping patterns and farm income.

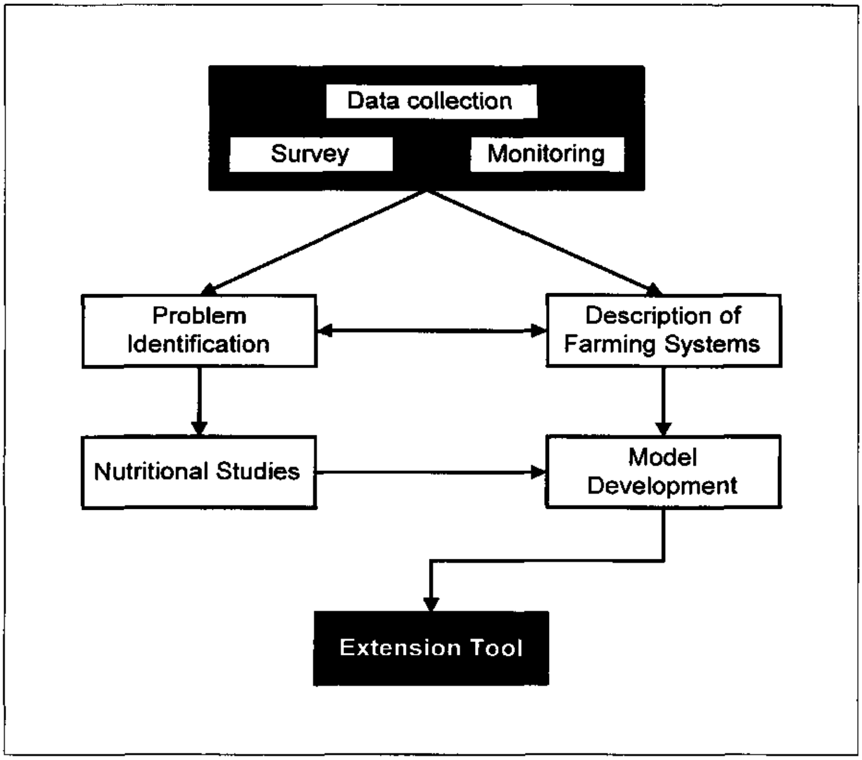
A better understanding of the last two might be achieved through the development of a mathematical model. Initially, this should enable feed mix and cropping pattern scenarios to be evaluated. Subsequently, with the availability of improved technical data on the production response to the feed, and the constraints, either real or perceived, faced by small farmers in adopting the technology, the model could be used as a direct aid to extension staff for assisting individual farmers in their crop/livestock management decisions.

This study aims at investigating various feeding strategies to meet animal requirements and to examine their impact on gross and net farm income. It focuses primarily on the inclusion of maize silage in the diet. The ultimate objective is, however, to produce a tool, in the form of a computer model, that can be used for both general investigative work and for specific farm situations, to predict the impact of changes in the livestock feeding system on the profitability of mixed dairy/crop enterprises in Egypt.

The study can be divided in the four following discrete, but inter-related components:

- the first part aims at producing a conceptual framework and description of Dairy-Crop Mixed Farming Systems in Egypt; this is to be based on the analysis of time series data collected from small and medium scale mixed farms over three years;
- the second part involves nutritional studies on the impact of introducing various levels of maize silage into the existing feeding system;
- the third part involves developing a descriptive mathematical model of the farming system, based on the survey data and the data from the nutritional studies. The model will also include the facility to assess the impact, in nutritional and economic terms, of introducing other forage crops and feed resources into the mixed dairy farming system;
- the fourth part involves refining the model to enable its operation at farm level, by advisory and management staff, as a "decision support tool".

The following chart illustrates the outline of the study.



Formulation of the research project

The first phase of the project is planning, appraisal, and design. There are three basic tasks in this phase: 1) identification and formulation of the project, 2) feasibility analysis and appraisal of the project, and 3) design of the project (Louis and Ralph, 1980). Table 1.1 summarises the three basic tasks of the proposed research project that is the subject of this thesis.

The first joint task (identification and formulation) involves the actual conception or identification of the project, entitled "Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems in Egypt". Formulation of the project involves developing an objective statement in broad terms "Promote efficient dairy farming", which expresses the objectives and also provides an estimate of the various resources required to achieve the project objectives, i.e. "farming system research and technology" through results/outputs.

The second task (feasibility and appraisal) was approached systematically by identifying the professional research team, the limits imposed by decision makers, and preliminary estimates of the resources required and time.

The last task identifies the activities to be carried out in operational form. Also, detailed specifications of the activities are given.

WAU/APRI-FSDP	Ph.D. RESEARCH PLANNING MATRIX	DEVELOPMENT OF A DECISION SUPPORT SYSTEM FOR DAIRY FARMS IN MIXED IRRIGATED FARMING SYSTEMS IN EGYPT	Duration: 1997-2001
SUMMARY OF OBJECTIVES/ACTIVITIES	**OBJECTIVELY VERIFIABLE INDICATOR**	**MEANS/SOURCES OF VERIFICATION**	**IMPORTANT ASSUMPTION**
OVERALL GOAL Promote efficient dairy farming development	**INDICATORS** Evaluate new interventions, contribute and/or propose plans for livestock development	Reports of WAU and FSDP	The research project fits into WAU/ FSDP over all objectives
PROJECT PURPOSE Assistance to Egyptian dairy sector through farming systems research and technology evaluation	**INDICATORS** Research program, based on farming systems analysis, agreed between WAU and APRI/FSDP.	Ph.D. thesis are completed by June 2000	First and second period funded by FSDP, third period funded by WAU
RESULTS/OUTPUTS - Animal production systems are classified and potential target for future development is identified. - Data on mixed crop-dairy farming systems are documented and made accessible. - Resource management problems and constraints are specified and solutions and/or interventions are proposed. - Decision support system model for	**INDICATORS** - Articles on animal production systems are drafted and revised by February 2000. - Article on mixed crop-dairy farming systems in north Egypt drafted and revised before February 2000 - Model on crop-dairy mixed farming system is developed and operational by the research team, submitted for publication by June 2000. - Article summarizing the results of on-farm trial is drafted and submitted for publication by May	- Working document/work plan and time schedule are prepared and operational - Regular communication /consultation between the members of the research team - Updating reports on the achievements of the research activity - Results in the form of scientific articles are reported. -First draft of the thesis ready by March 2000 - Thesis is completed and ready for defense before June 2000	Funds are available; field work is implemented as planned

individual dairy farms was developed, taking into consideration the intervention. - Technical adoption of the proposed intervention was measured and the influencing factors were identified. - Detailed information on maize silage and interactions under local conditions is provided. - Nutritional feasibility, economic profitability and farmer acceptability of the intervention are provided.	2000 - Articles summarizing the on-station trials are drafted and revised by the end of March 2000. - Article on evaluation of maize silage is drafted and revised by March 2000 - Article on the implication of maize silage on farm resources and farmers response		
ACTIVITIES - Study the role and potential contribution of mixed dairy farming to the agricultural sector. - Qualitative and quantitative description of the mixed crop-dairy farming system. - Identify problems and constraints of small and medium scale mixed farming. - Develop a decision	**SPECIFICATIONS** - Emphasis on aspects related to the development of livestock sector, classification and brief description of the animal production systems in different agro-ecological conditions involving different socio-economic groups. - Identification and description of the management practices of small and medium scale farm households; establish hypothetical boundaries of the two inter-linked subsystems (Crop-Dairy). - Focus on management limitations that result in sub-optimal resource uses, availability of improved technology, outline procedure to optimize farm resource use and evaluating the inclusion of maize silage as intervention. - Maximize farm profitability from both crop and	Reports provided by promoters/research leader	Local official statistics are accessible. Local funds are available for fieldwork and monitoring. Fund, vehicle, official authorization and approvals are provided to interview farmers in different districts. Office facilities

support system for individual dairy farms in mixed irrigated farming systems.	dairy farming, formulating and testing different management strategies at farm level and measure their impact on profit; predict animal production, nutrient requirements and construct the optimal cropping pattern based on least cost ration formulation.		e.g. computer and software are provided
- Conduct on-farm trials on selected intervention (maize silage).	- Evaluate the quality of maize silage made by farmers compared with on station silage making and identify quantitatively factors influencing the quality of silage on-farm.		Animals, laboratory facilities and chemicals are provided by APRI
- Detailed nutritional evaluation of maize silage and interactions/impact under prevailing conditions.	- Undertake detailed analysis of the conservation process, digestibility, intake and feeding values of maize silage.		
- Assess nutritional feasibility, economic profitability and farmer acceptability of the intervention.	-Inclusion of maize silage in the diet to meet animal requirements at various levels of milk production, examine the impact on the feeding costs, farmer reaction/response to the new technology.		

Chapter 2

Animal Production Systems in Egypt: Their roles, classification, description and potential contribution to development

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Animal Production Systems in Egypt: Their roles, classification, description and potential contribution to development

Summary

This paper focuses on aspects related to the development of the livestock sector in Egypt, with emphasis on animal production systems. Based on studies of official statistics, published articles, observations and experiences, the authors were able to classify and describe the animal production systems in different agro-ecological conditions involving different socio-economic groups. Two inter-linked criteria were used to classify the animal production systems: a) degree of capital intensification, (intensive, semi-intensive or extensive); b) the economic objective of the holders. This may be either of a subsistence, semi-subsistence, semi-commercial or entirely commercial nature.

This paper demonstrates the role and place of the livestock sector and its contribution to the national economy, as well as the development of external trade in milk and dairy products in the past 10 years. The potential for dairy improvement is discussed and it is concluded that rapid population growth along with social and economic changes will increase the demand for animal products.

The vision recognises that as intensification evolves, the predominantly traditional systems will change into systems that are more heavily dependent on external inputs and improved technology. This paper is strongly recommending that the traditional mixed farming systems which represent over 70% of the livestock sector are studied in detail, to enable developing farm models that can help the decision-makers at farm level to maintain high productivity.

Introduction

Historically, Egypt is known as one of the oldest agricultural civilisations. During the last 200 years, the economy has diversified and the importance of other, non-agricultural sectors, increased. However, agriculture remains an important sector of the Egyptian economy, employing 4.7 million workers, with an annual growth rate of about 0.8% and generating 20% of its GNP (Gross National Product). The annual growth rate for the Gross Domestic Production (GDP) is 3.7% in year 1997/98. The country is self-sufficient in fruits and vegetables, but produces only 30% of its requirements in wheat and 66% in maize. Production increase, through the combined effect of area expansion and yield increase, can not keep up with population growth, so that Egypt will continue to depend on imports for a considerable proportion of its food supplies. Consumer prices for bread are subsidised, but for meat, milk, vegetables and other food commodities, they are determined in the free market.

The total cultivated area during 1997/1998 was 7.9 million feddans (6.3 irrigated and around 1.5 rain-fed; a feddan is 4200 m^2) including the newly reclaimed land, while the harvested area was 14.2 million feddans. The agricultural sector is aiming at increasing output by 4.1% per year. The government began to implement many agricultural national projects in the field of land reclamation and cultivation aiming at increasing the cultivable area during the next twenty five years by nearly 3.4 million feddans of which 2.3 million feddans in the southern valley and north Sinai.

Average farm size is very small, two to three feddan, but, under irrigation, each year at least two crops, a winter crop and a summer crop, can be harvested. In the basin of the Nile River and its delta, about seven million feddan of land are available for irrigated agriculture. In addition, around 1.5 million feddan of former desert land has in recent decades been brought under irrigation.

Although in the winter season a large proportion of the land is cultivated with the forage crop berseem *(Trifolium alexandrinum)*, in economic terms, animal production is less important than arable farming. This is mainly due to the generally medium to low level of production (average estimated milk production per lactation in 1998 ranged from 1946 to 2540 litres; for cross breed, 1511 to 2190 for buffaloes and 950 to 1228 for local breed) of the 3 million cattle and 3 million buffaloes held on small farms. Thus far, agricultural extension and development have mainly focused on cereals and cash crops, leaving the cattle and buffalo without major technological innovations. Modern dairy farming exists, but comprises only about 100,000 dairy cows. As a result, the country is to a substantial extent dependent on imports for the supply of meat and milk. The aim of this review is to describe the existing animal production systems, their relative importance and the potential for dairy development.

The place of livestock

Agriculture is the dominant sector in the economy, where today 53 percent of the population lives in rural areas. Output of livestock commodities meat, milk, eggs, wool and skins accounted for 25 percent of agricultural domestic production.
Livestock population development over the period 1976-1997 is indicated in Table 1. Cattle and buffaloes comprise over 70% of the total population, expressed in animal units (AU). The buffaloes (35.5%), and 26.4% of the cattle are considered dairy animals, making the dairy sector the main animal production activity. The size of the population, the area for forage cultivation, and the availability of new technology suggests that there should be an enormous potential for development.

Table 1. Development of livestock* population (, 000) in Egypt during 1976-1997.

Year	Cattle	Buffaloes	Sheep	Goats	Camels	Non-ruminants
1976	2,079	2,226	1,878	1,349	101	1,528
1978	2,587	2,542	2,554	1,440	93	1,685
1980	2,423	2,009	2,488	2,409	126	1,719
1984	2,782	2,531	2,479	2,387	146	2,239
1989	2,722	2,864	3,481	2,000	n.a[b].	n.a[b].
1991	2,719	3,165	3,148	2,442	147	1,587
1995	2,996	3,018	4,220	3,131	131	1,354
1997	3,118	3,096	4,260	3,187	136	1,475
AU**[a]	3,117	3,095	852	478	284	885
AU%	35.8	35.5	9.8	5.5	3.3	10.1

Source: Central Department of Agricultural Statistics, Ministry of Agriculture and Land Reclamation, Cairo, bi-annual series volumes from 1976 to 1997.

* Excluding poultry

** Animal Unit (AU) calculated as 1, 1.2, 0.2, 0.15, 1 and 0.6 for cattle, buffaloes, sheep, goat, camels and non-ruminant animals, respectively.

[a] referring to 1997 , [b] not available

Historically, the most significant role of livestock has been in support of arable farming, in both physical and socio-economic aspects. Animal manure played a crucial role in soil fertility management, by restoring part of the nutrients that crops removed. Additional nitrogen was supplied through fixation by the berseem. Until only a few decades ago, animals provided almost all draft power. Through their role as a capital asset (Bosman et al., 1997; Slingerland et al., 1998), livestock significantly contributed to the economic stability of farm enterprises, serving as 'living banks', providing financial reserves for periods of economic stress and a buffer against sometimes non-remunerative crop prices. Animals thus provide a flexible source of cash, enabling farmers to purchase inputs and meet other urgent needs. Furthermore, they provide a means to profitably use farm labour during periods when it is not needed for cultivating or harvesting crops (Savadogo, 2000).

External trade in milk and dairy products

Currently, as over the last 10 years (Table 2), Egypt imports dairy products to a value of about 500,000,000 E annually (1 E = 0.34 US$), representing 43% of its total requirements (1996), mainly in the form of milk powder (various fat percentages), butter oil and various types of cheese. Imports to that extent, may be expected to lead to low domestic prices and disincentives to local production, especially when export of dairy products is stimulated by subsidies from the exporting countries (de Jong, 1996).

Table 2. Value (000, E)[a] of external trade in milk and dairy products*

Year	Imports	Exports	Export :import ratio
1990	551,649	5,968	0.01
1991	405,739	16,248	0.04
1992	524,948	15,230	0.03
1993	503,239	15,684	0.03
1994	509,404	19,898	0.04
1995	573,767	9,144	0.02
1996	659,821	14,711	0.02
1997	505,560	15,053	0.03
1998	505,569	12,116	0.02

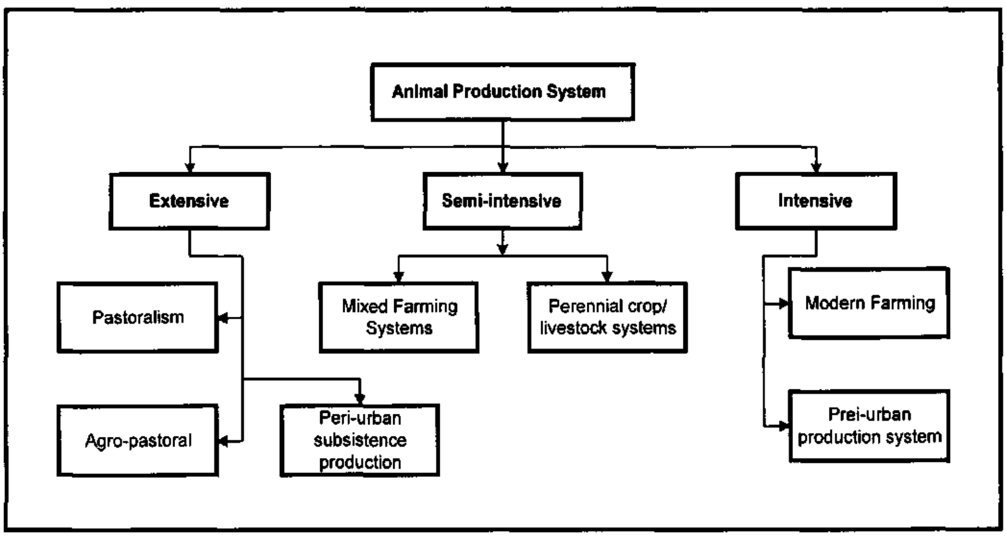
Source: Central Agency for Public Mobilisation and Statistics (CAPMAS) database, September 1999

[a] 1 E = 0.341 U$

* CIF (cost, insurance and freight) for imports, FOB (free on board) for export.

Classification of animal production systems

Figure 1. Schematic representation of the classification of animal production systems



Classification criteria

From the many classifications of animal production systems proposed, in this paper a slightly modified version of the system described by Jahnke (1982) has been used (Figure 1, Table 3). This classification system meets two requirements: a) the degree of intensification in terms of capital investment (intensive, semi-intensive or extensive), and b) the *economic objective of the cattle* owner (subsistence, semi-subsistence, semi-commercial or entirely commercial).

Table 3. Number of animals and animal units (, 000) in the classified systems

	Pastoral	Agro-pastoral	Mixed	Integrated	Peri-urban	Modern
Baladi	3	60	1603	550	78	---
Pure	---	---	---	---	---	100
Cross	4	31	533	148	8	---
Buffaloes	3	20	2141	782	149	---
Goats	495	83	1526	981	103	---
Sheep	758	63	2424	902	113	---
Camels	72	967	212	24	7	---
Donkeys	24	16	1036	339	62	---
Animal Units						
Number	315	134	8637	1925	265	120
%	3	1	76	17	2	1

The boundary between a semi-subsistence and semi-commercial system is set to 50% sale of total production. The classification remains rather arbitrary though, as no accurate statistical data are available on sales of Egyptian farmers. Most commercial producers specialise, focusing on cattle, while subsistence, semi-subsistence and semi-commercial producers may utilise several types of domestic livestock, depending upon their economic-cultural system and environmental conditions. The dominant animals in the pastoral system are sheep and goats, while camel is the dominant animal in the agro-pastoral system. In terms of animal units, 76% of the total population is included in mixed farming systems, followed by integrated farming (17%). The other systems play only a minor role.

Extensive systems

Subsistence

The primary purpose of subsistence-oriented production is to meet family needs. It involves little or no commercial exchanges.

Pastoralism

Pastoralism is of marginal importance in Egypt, comprising about 3% of the total animal population. Pastoralists are concentrated in the northern part of Egypt (near the Egyptian-Libyan border) and in the Sinai Peninsula, though small numbers of pastoralist families are scattered throughout the drier areas. Pastoralists keep camels, donkeys, sheep and goats. Their breeds can survive under arid and semi-arid conditions, produce some milk, even if poorly fed, and are very fertile (reproductive) under improved feeding conditions. In fact, most of the pastoral breeds are more suitable for meat production.

Most pastoral animals graze in groups, belonging to one holder or one family, moving quickly over the pastures. They often browse during the dry season and graze low quality herbage when available. They may walk considerable distances during the day, usually drinking only once and, if water is scarce they may not be allowed to drink for 2 to 3 days. At night, the animals are kept in camps as one group or sub-divided in several groups each provided with its own enclosure.
The grazing land is a communal resource while livestock are owned individually or by family units. Usually, water resources are also communally owned, though in a few areas they belong to individuals or families. The number of livestock owned by the family is therefore not regulated by the carrying capacity of the grazing land, but by the managerial skills of the family unit.

Social and economic traditions that encourage and assist families to maximise herd size have been retained, despite overstocking, not only to ensure adequate food and income but also family survival in times of disaster.

Agro-pastoral systems

Agro-pastoralists are sedentary farmers that cultivate food crops (mainly barley) both for subsistence and for sale. These systems typically occur where extensive rainfed cropping is possible, i.e. in Egypt in some locations along the Mediterranean coast. This system prefers indigenous cattle that are already utilized by pastoralists in their regions. At present, their cattle are triple-purpose animals (meat, milk, and work). The owners herd their animals, camels, indigenous cattle breeds, sheep and goats, on communal land near their permanent cropping areas, on the fallow during the winter season and throughout the area during the summer season after the crops have been harvested. Indeed, in these places some farmers keep permanent plots under irrigation (using fossil water resources) to be used for crop production and to graze livestock.

The major technical objectives of this management are to maintain and if possible to reduce annual fluctuations in cattle numbers and seasonal fluctuations in live weight, maximize reproductive performance and minimize mortality. All these managerial practices tend to intensify production as a result of increases in herd size and thus increased stocking rates.
Men usually herd mature cattle, while women and/or children tend calves and sick animals.

Peri-urban subsistence production

Many urban families keep a few chickens, and/or two to three sheep or goats for occasional home consumption. Little or no investments are made in their feeding or health care. The animals scavenge for a large part of their required feed, but are supplemented with available household and kitchen waste. Performance is therefore poor and mortality high.
Subsistence production is seasonal: dependent on variations in the household budget, occasions in the religious calendar and more irregularly, events to celebrate, such as a wedding.

Semi-intensive systems

The main characteristic of these semi-intensive systems is the use of 'intermediate levels' of external inputs along with the following features:

- Holdings of relatively small size.
- A mixture of subsistence, semi-subsistence and cash economies, though pure subsistence economies have almost disappeared.
- Milk production as the main objective for livestock keeping, though also draught power continues to play a role.
- Meat from sheep and goats plays a minor role compared to cattle.
- Beef is only a 'by-product' originating from old and culled milk cows.
- Emphasis is on the use of agricultural and industrial by-products as feed rather, than on grazing.

Mixed farming

The mixed crop-livestock system is the most important cattle production system, representing over 70% of all cattle in 1997, together with large numbers of buffaloes and some sheep and goats.
It is the predominant system in the Nile basin. Arable farming, of both food and cash crops is the main agricultural activity. Farm size is usually small (1-5 feddan) with high

cropping intensity. Livestock serve arable farming through utilisation of crop residues, partly for the recycling of nutrients to maintain soil fertility and providing additional income in the form of milk and/or meat (Savadogo, 2000). Within this system, buffaloes are kept for milk production and cattle are bred for double purpose, to gain body weight and produce milk during their lifetime, being slaughtered when too old. In some situations, cows are expected to provide draught power, if mechanisation is not available.

The dominant animals are buffaloes, baladi cattle and cross breed cattle that are locally available. In areas such as Damietta (northern district of El-Delta), where milk production is promoted by governmental and/or foreign aid projects, and AI (artificial insemination) or genetically improved bulls were used for almost 20 years, crossbreeds are primarily used in addition to the buffaloes. However, attempts are also being made by governmental and/or non-governmental organisation to establish pure breed and high-grade herds of European breeds through imports and AI programs.

The majority of the farmers milk their cattle twice a day – in the morning (calves are allowed to suckle before milking) before they leave home where they are kept at night, and in the evening upon return from the shades where they are tethered during daytime. These shades often are located at the edges of crop fields, if cut and carry systems are applied, restricted grazing systems can also be found when shortage of labour exists.

Feed quality strongly varies with season, with the best feed available in winter (fresh berseem). In summer, on the contrary, animals are mainly dependent on straw-based rations, supplemented with small quantities of grown forage, mainly in the form of densely sown maize, used for fresh feeding at an age of 2 months (called darawa). The management of feed supply is fully adapted to this 'regular' pattern in feed availability. The animals respond to the variation in feed supply by adjusting milk production and fertility.

Results of surveys have indicated that about 63 percent of the calving occurred during the colder season (El-Sheikh, 1987; Tabana, 1998). Mostageer et al. (1981) carried out a study on two groups of approximately 200 females each, located in the same estate farm, fed berseem in winter and darawa in summer. Average milk yield was higher and the lactation period longer in females calving during the colder season than in those calving in the hot season: 1309 versus 1147 kg and 233 versus 200 days. This agrees with the findings reported by Tabana in 1998 (with significantly higher levels of milk production) on the basis of an on-farm monitoring program over a period of 4 years.

The variation in feed availability between seasons was more pronounced in the past than at present. In particular before construction of the Aswan High Dam, seasonal flooding of the Nile occurred. The local breeds appear to be used to these variations, and tolerate seasonal deficiencies in nutrition. However, long calving intervals, delivery preferably in winter and relatively low milk production was a normal performance pattern. This inherited pattern of poor reproductive and productive performance continues to limit productivity on traditional farmer holdings. As a result, especially among the smallholders, in winter seasons there may be a surplus of milk to sale or home processing, while in the summer a precarious balance has to be established between the calves' intake and the off-take for humans.

The major problem to achieve significant development in the dairy sector is the small size of the holdings, that is the result of the inheritance system, along with the pressure of population on limited land resources. Thus, intensification of agriculture such as the production of fruit and vegetables is widely practised to increase cash income for the small farmer.

Similarly, milk production could be a very suitable activity to generate regular cash income for small farmers, if collection, processing and distribution could be properly organised. Before modern dairying techniques can be applied, systems of semi-intensive and intensive herd management need to be adopted for regular, non-seasonal production. An optimum feeding regime of concentrate rations and cultivated green fodder is necessary throughout the year, and proper housing would also be beneficial. *Special managerial arrangements will have to be made to meet the technical* demands of intensive buffalo farming.

For meat production, three types of fattening activities are practised, separately or in sequence:

a) From birth to weaning. This type of veal production starts with a special calf-rearing program. Initial birth weights are around 35-38 kg for buffaloes and 25-28 kg for baladi cattle. Farmers are aiming to reach 100-120 kg within a period of 90 to 100 days. Calves are fed initially about 50% of the milk produced by their mothers, i.e. two teats until 45 days, then three teats until the 75^{th} day, followed by the full udder till the end of the fattening period. In addition, high quality concentrates (mainly wheat bran, cotton seed cake and ground maize) are used to feed the calves at a daily rate of 2% of their body weight. Green forage and good quality hay are fed in very restricted quantities, if used at all.

b) From weaning age to eight months. This starts from weaned calves, in a range of 100-120 kg body weight to reach 250-260 kg within 6 months post-weaning. The feeding systems strongly vary among areas, depending on the type of concentrate feedstuff available and season. Berseem (clover) is the main fodder offered during winter and darawa (growing maize) in summer. In some areas, where maize silage is promoted such as Shanshor, Monofie governorate, maize silage along with home manufactured or purchased concentrates are commonly used for growing animals, either with berseem in winter or between the summer and winter seasons, whenever green forages are not available.

c) From eight to twelve months. This stage of fattening is oriented by market demand. When price of meat is high due to special occasions such as Aed El-Adha, farmers tend to increase the use of good quality concentrates to maximise the growth rate of the animals and decrease the use of green forages. The opposite occurs when the demand for meat is low, farmers tend to increase the fattening period by using less concentrate and more forages. The final weight is normally over 400 kg.

Perennial crop-livestock integrated systems

An example of this system is the sugar cane-livestock system, prevalent in several districts in Upper Egypt. Sugar cane provides three feed by-products: green tops, molasses and bagasse, that are all three commonly used in Egypt. Sugar cane tops are used as fresh forage, and still rarely, as silage. Molasses are supplemented by urea as source of non-protein nitrogen (NPN), minerals and vitamins and are distributed to farmers at some locations, but unfortunately not yet in the cane growing areas. The molasses mixture is also used to feed fattening beef cattle. Bagasse is used to a limited extent as a source of roughage in feedlots and other rations.

Intensive systems

Intensive dairy farming

Farmers practising this system use large proportions or all their land to cultivate fodder crops for their dairy cattle and, in addition they usually feed purchased concentrates. They may also use part of their land for food or cash crops. Manure is used for growing fodder and other crops; milk is a major source of farm income. Intensive dairy farming is practised mainly by small farmers who use family labour, but it is also undertaken by large farmers who employ hired labour.

Peri-urban milk production

Peri-urban milk production has developed around cities and towns, in response to a high demand for milk. The main feeds are agro-industrial by-products that are available in the cities (e.g., brewery waste, oilseed cakes) and cultivated fodder crops or crop residues. Although dairy production can sometimes compete with vegetable production for land, it can also support the production of horticultural crops by providing manure. Milk is often traded directly or through middlemen to the consumers in the city and is the major source of income for the farmers. Family members are required mainly for feed collection and/or to feed the animals.

Modern Production Systems

There are two major activities of the modern sector of cattle production, dairy farming (dairying) and intensive beef production. These systems adopted concepts and management procedures from the western farm management styles.

Potential for dairying improvement

McIntire et al. (1992) reported that as population pressures cause animal production systems to become more intensive, mixed crop-livestock becomes a more efficient and sustainable means of increasing off-take from a fixed land area than specialised systems of crop and livestock production. These investigators found that under low population densities and low disease stress, specialised herding and crop cultivation systems are more efficient than integrated systems.
The potential for improvement depends to a large extent on the production system. In the pastoralist and agro-pastoralist systems, productivity is low and highly seasonal, because of the rainfall pattern and the associated fluctuations in feed availability. Very little external inputs are used and little or no control exists over the feed resources and consequently few opportunities for commercialisation. Collection of milk for processing is difficult due to the mobility of the producers in the pastoralist system and/or the limited surpluses available after family subsistence requirements have been met, in addition to the seasonal availability of milk in both systems.
In the mixed farming systems, feed availability could be improved through feed storage, crop residues and fodder crop cultivation. That would provide opportunities to diversify operations, to spread risks and generate a regular income. Production and sale of milk may be stimulated by the establishment of a collection/processing infrastructure and by payment of good prices for milk.

Conclusion

The rapidly growing human population of Egypt is driving major demographic, social and economic changes that will lead to transformation of agriculture systems. In order to satisfy the growing demand for agricultural products, agricultural systems will have to be intensified. The vision recognises that as intensification evolves, the predominantly traditional systems will change into systems that are more heavily dependent on external inputs and improved technology. The specific technology that will eventually be required to reach the optimum level of resource use still must be developed. It is clear that livestock have an essential role to play in the agriculture of the future in Egypt.

There are excellent possibilities for increasing production of food and animals with the most promising being (1) expansion of crop-livestock farming, (2) increased productivity through expanded use of technology and inputs. This requires that the traditional mixed farming systems be studied in detail and if possible simulated/modelled. If these models are developed, they may help the decision-makers at farm level.

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Chapter 3

Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems: I. Qualitative and Quantitative Description of the Mixed Crop-Dairy Farming Systems in Lower Egypt

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Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems: I. Qualitative and Quantitative Description of Mixed Crop-Dairy Farming Systems in Lower Egypt

Summary

This paper demonstrates a farm management information system in the context of a mixed farming system in the northern part of Egypt. The management issue considered is divided into two inter-linked enterprises (Crop-Dairy). It is based on the analysis of time series data collected from small and medium scale mixed farms over three years. An identification and description of the management practices of each sub-system resulted better understanding of the dairy farming systems and established the boundaries of the components that are used as the base for modelling the whole farming system. The constraints of the systems were also identified with special attention for feeds and feeding. Finally, the authors used this information to construct nutritional studies along with other information published in a scientific article to develop a decision support system for crop-dairy mixed farms.

Introduction

In Egypt, agriculture is concentrated in the Nile valley and delta. The climate and the availability of irrigation water permit cropping year-round. As illustrated in an abundance of preserved pictures and sculptures from the Pharaonic era (on display in the Cairo Agricultural Museum and in the Egyptian Museum), in the Nile basin a mixed farming system developed several millennia ago, with clover being used in winter as a forage crop. This mixed system has survived until today. While in recent decades the importance of animal draught power has sharply declined, dairy farming and meat production remain important activities for many farmers.

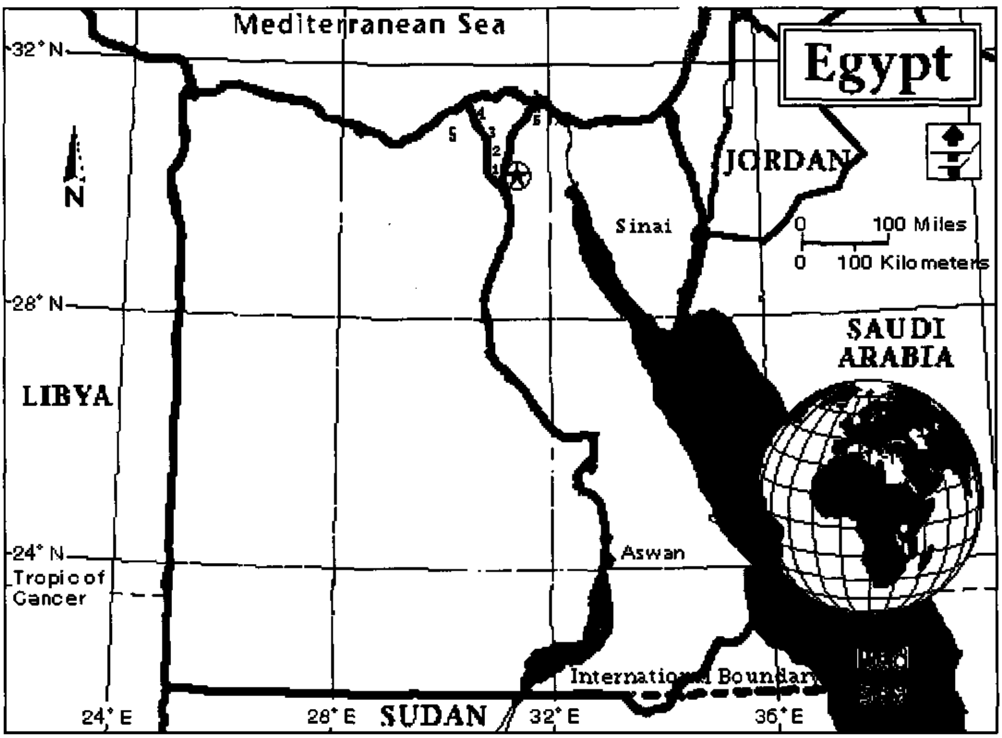
Crop-livestock farming systems are major components of agricultural production systems (FAO, 1982). Dairy farming is an important activity for many farmers in Egypt, where mixed crop-livestock farming is practiced traditionally. Quantitative shortages, and poor quality of feeds and fodder, as well as imbalanced diets affect the performance of dairy animals through both under- and overfeeding. These practices have a negative effect on the economics of milk production, as has the competition from annual staples and cash crops. Dairy farming is a business and the objective is maximising overall profit, rather than the feeding of cows to realise some national yield (Mainland, 1994). Decision-making aiming at profit maximisation in an environment that involves multi purposes of the family and the farm is difficult. Computerized farm records have failed to meet the needs of the 'average' farmer for decision-making support (Hardaker & Anderson, 1981). This problem must be resolved, so farmers can

respond to the increasing pressures to substitute inputs in the agriculture production process (Sonka, 1985). To provide appropriate management decision support to the farmer, the whole farm enterprise should be modelled (Sitaramswamy & Jain, 1993). Such models should be based on analysis of the mixed dairy farming system, taking into account the interactions between household, crop and livestock subsystems.
The objective of this paper is to identify and describe the management practices applied in each subsystem, to gain a better understanding of the dairy farming systems and to establish the boundaries of the components as a basis for modelling the whole farming system.

Methodology

The information was obtained from data collected in six areas (districts/sub-districts) located in northern Egypt (1 Menoufeia/Ashmoun, 2 Dakahlia/Senbellewien, 3 Kafr el Sheikh/Qallin, 4 Gharbia/Quttur, 5 Alexandria/Nubaria, 6 Damietta/Faraskor), as shown in Figure 1.

Figure1. Map of Egypt with the location of study areas.



A Rapid Rural Appraisal (RRA) technique was used in the selected six study areas. Seventy-two farmers were selected to identify the main characteristics of their dairy farming system. Out of these, 36 farms were selected, using special criteria for dairy farming e.g. 1) cultivated area; 2) number of adult dairy cows; 3) amount of milk sold (Table 1). Basic data covering three years (1995-1997) were collected through individual monthly meetings with farmers. Six field research officers, and twelve extensionists, under the supervision of the Dairy Systems Analysis Unit (DSAU) of the Food Sector Development Programme (FSDP) of the Animal Production Research Institute (APRI), were involved in data collection. Frequent interviews with farmers, using a questionnaire, were also carried out to collect additional quantitative data and information related to crop and livestock production. The set of data that was collected to meet the objectives of the study consists of :

- Animal data (herd: birth, mortality, sale; breeding: natural, AI; Animal production: milk, meat).
- Crop data (sowing and harvesting dates, yields, crop area, type of forages: conserved or treated).
- Economic data (forage and feed purchases, milk marketed excluding home consumption/processed milk, prices).
- Time allocation for the various farm activities. Samples of feed stuffs were taken and analyzed.

Table 1. Number of farmers and criteria used.

Item	Small scale	Medium scale
Number of selected farmers per area	4	8
Criteria:		
- Crop area (feddan*)	<2	2-10
- Number of adult animals	2-4	4 - 15
- Quantity of milk sold (L/d)	5-20	>20

* One hectare equals 2.4 feddan

Cropping subsystems

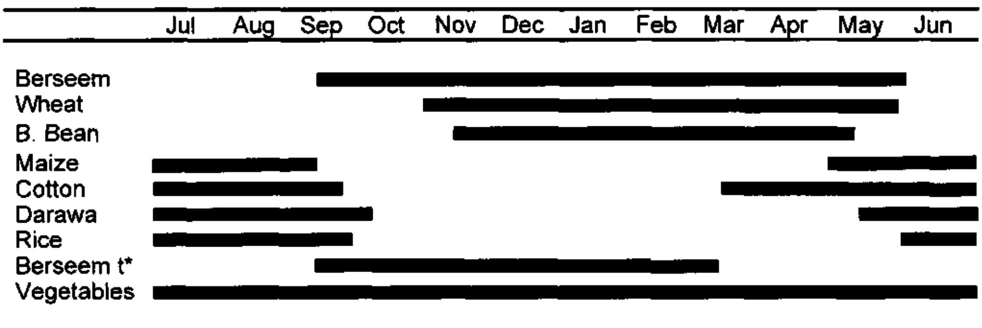
Egypt is known as one of the oldest agricultural civilisations (CIHEAM, 1992). Total land area is around 1 million km^2, but only 2.61 million ha or 2.6% of the total area is cultivable (FAO, 1992). Agriculture has been transformed through the introduction of modern farming equipment and management techniques. Multi-cropping systems are common in all areas and fodder crops and horticultural crops are inter-cropped in some areas. Almost all the cultivated land uses surface irrigation systems. An exception is the small horticultural area located in the newly reclaimed land (desert), where drip *irrigation systems are used. Because of water availability year-round and the length of* the crop cycle, significant variations exist in sowing and harvesting dates within geographical areas.

The main agricultural commodities typically belong to one of the following groups:

1) Annual staples: wheat, broad bean, maize, and rice
2) Fodder crops: berseem (*Trifolium alexandrinum)*, darawa (vegetative maize), and multi-cut summer forages, such as millet
3) Vegetables: tomato, potato/sweet potato, onions, and watermelon or cucumber.
4) Cash crops: cotton, sugar cane, sugar beet

The common cropping patterns for the farmers were [fodder - food crop] in winter and [food crop/cash crop – fodder] in summer. Figure 2 represents the common cropping calendars.

Figure 2. Cropping calendars of the main agricultural commodities.

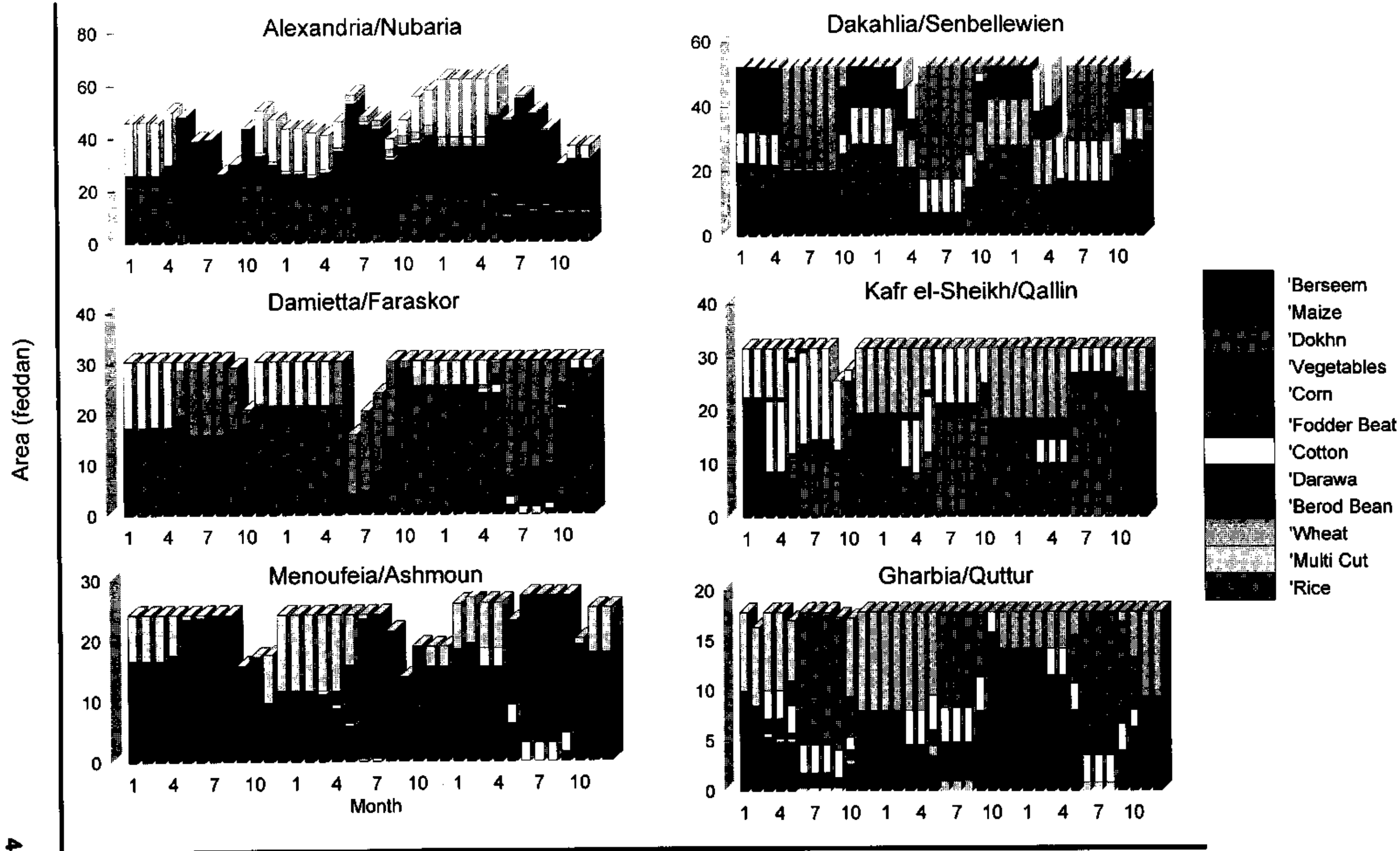


* Berseem Tahreesh is mainly cultivated for short periods (1 or 2 cuts) before cotton for soil fertility purposes.

The number of cultivated plots varied from farm to farm and was influenced by total farm size, land ownership /inheritance system, policy, or household needs.

In the family-owned and -operated enterprises, with various levels of capital investment, few alternative exist, under current infrastructure, water availability, soil fertility *and market conditions. The current crop rotations typically are:* berseem-rice/berseem-cotton/berseem-maize/wheat or broad bean-rice. Darawa or vegetables can be cultivated instead of any other crop when the temperatures are suitable for sowing and growth. The general quantitative pattern of crop area and rotation of the monitored farms in each of the districts are shown in Figure 3.

Figure 3. Quantitative cropping pattern (three years intervals) of the study areas



Livestock subsystems

Baladi (traditional cattle breed), Friesian cross Baladi and Buffaloes are the dominant large ruminants in the study areas. Buffaloes are preferred as milking animals for home consumption and to supply the local market with liquid milk. Cross breed cattle as well as pure Friesians are preferred as milking animals on commercially oriented farms. Baladi cattle have been intensively used for draft purposes, but at present their main use is for meat production. Natural mating is predominant and hand milking is performed twice daily, if calves are not present.

Small farmers and landless rural people mainly keep sheep and goats. One or two productive female animals are usually kept for reproduction. For young males, a short period of fattening is practised before slaughtering. This fattening is undertaken at opportune periods, depending on the household budget situation and on occasions in the religious calendar and more irregularly, on celebrations of among others weddings or births. For instance, two or three months before *Aid el Adha* (sacrificial festival), at which meat is traditionally eaten, some families buy lambs or sheep for fattening.

The herd structures found among the dairy farmers in the study areas are shown in Table 2.

Table 2. Average herd size and structure for different geographical areas and farm sizes[2].

	S.	M.	Men.	Sim.	Quall.	Qut.	Nub.	Dam.
Lactating animals								
Buffaloes	1.48	3.24	3.20	4.97	1.64	1.09	4.69	0.95
Cattle	0.73	4.48	1.62	0.97	3.76	3.97	3.65	6.72
Total Lactating	2.21	7.72	4.82	5.94	5.40	5.06	8.34	7.67
Young animals								
Heifers	0.20	0.81	0.33	1.33	0.50	0.00	1.00	0.67
Fattening f.	0.17	1.42	0.50	0.00	0.00	1.00	0.67	1.50
Growing female	0.15	0.48	0.35	0.3	0.31	0.40	0.54	0.43
Growing male	0.15	0.53	0.65	0.46	0.33	0.19	0.43	0.43
Suckling calves	0.57	1.91	3.72	1.74	2.26	1.84	1.74	0.70
Total young	1.24	5.15	5.55	3.83	3.40	3.43	4.38	3.73
Other animals								
Donkeys	1.00	1.38	1.45	1.55	1.01	1.04	0.94	1.54
Sheep/goats	0.78	0.85	3.94	0.04	0.21	0.43	0.29	0.04
Total AU[1]	3.86	12.32	10.32	10.02	8.21	7.95	12.45	10.89

[1] 1AU= Cow producing 9 liters of milk/d with 500 kg body weight. Buffalo = 1.2 AU, Heifer = 0.8 AU, Growing animals = 0.6 AU, Donkeys and calves up to 7 months = 0.4 AU, sheep and goats = 0.2 AU

[2] S= small farms, M= medium farms, Sim= Senbellewien area, Qut.= Quttur area, Qall = Qallin area, Nub= Nubaria area, Men= Menoufeia area and Dam= Damietta area

The data show that lactating animals represent more than 50% of the total herd for both small and medium farmers. Also in all study areas, all farmers tend to breed their own young stock as replacements or for fattening. Buffaloes are the dominant animals in the areas located close to urban centres (e.g. Menoufeia, see figure 1), where milk tends to be sold as fresh milk (with 7% fat). Milk is mainly used for cheese making, and for sale as fresh milk through informal marketing channels.

With respect to herd size and structure in the course of the year, it should be noted that large modifications in the structure did take place, with limited changes in the size in all areas. This implies that the driving force for changes in herd size is the availability or lack of feed resources along with other, less important factors, such as animal housing facilities. Figures 4 and 5 present herd size by month and year, respectively (expressed in AU). The animal unit used, is based on standard requirements of Dry Matter (DM), Total Digestible Nutrients (TDN) and Crude Protein (CP) of a cow producing 9 liters of milk/day and a live body weight of 500 kg.

In general, animals are kept either as milking animals, when they are old which are sold for meat or as saving banks, sold when a large amount of cash is needed.. For old or growing animals, sales are made mainly during the transitional period (between summer and winter season), while productive adult animals are sold when they are pregnant or with calves at foot.

Examining herd dynamics over the three years (Fig.5), shows that on small-scale farms, herd size gradually tends to decrease over the study period. For medium scale farms, no clear trend emerges yet; more time is needed to establish any trend in herd size, if present.

Figure 4. Annual herd size dynamics for small and medium farms, averaged over years and geographical areas.

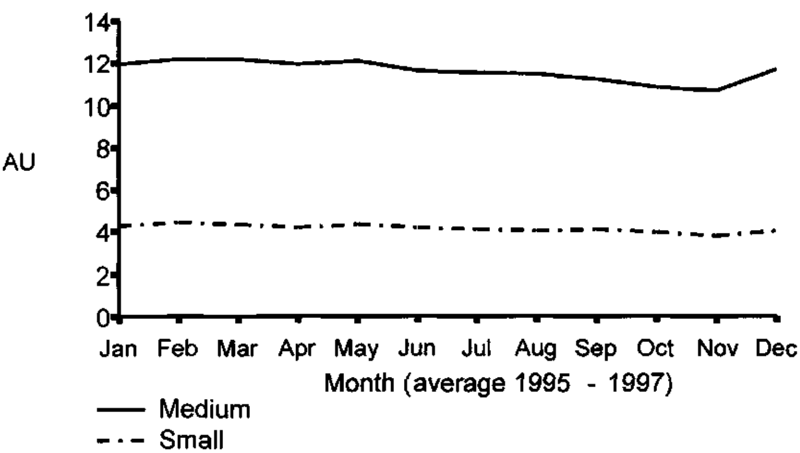
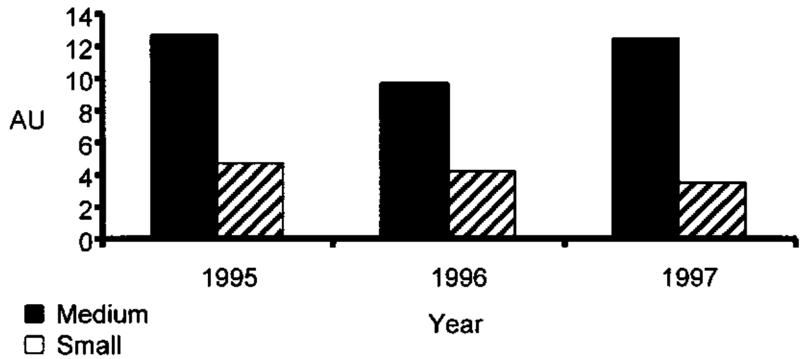


Figure 5. Herd size by year over three years for small and medium farms, averaged over geographical areas.



Milk production

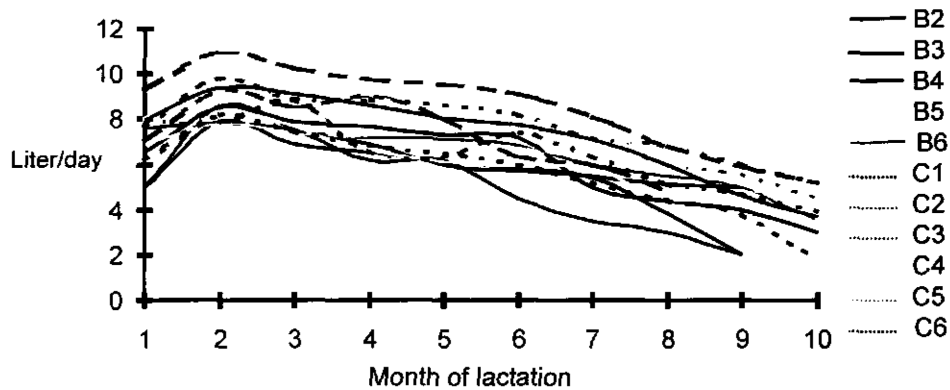
Estimates of milk production are based on monitoring at the sampled farms. This included direct observations of the cows and discussions with each farmer on its production, in combination with adapted recordings of animal performance. The sample farms were selected in such a way as to cover a range of management practices, thus enabling the use of comparative analysis, as a basis for the modelling of milk production. Table 3 represents average milk production per lactation and number of animals that completed lactation on the study farms in the period 1995 to 1997 in the six areas under study.

Table. 3 Average milk production (M, in kg) per lactation and sample size (N), per breed and study region.

Breed	Baladi		Buffalo		Cross	
Region	M	N	M	N	M	N
Ashmoun	1228	15	2190	24	2200	12
Senbellewien	950	1	1865	48	2120	7
Qallin	1050	6	1789	12	1946	25
Quttur	980	4	1511	7	2356	42
Nubaria	1180	3	1801	53	2357	38
Faraskor	1060	1	2109	7	2540	45

The complete lactation period (over 75% of the animals have a milking period of 10 months) has been worked out for the three years of monitoring. Relatively few animals were monitored during a complete lactation period, because some of these animals were sold or exchanged for others. Moreover, milk recording was started with animals in different stages of lactation. However, the data collected from the various farms have been sorted by month of lactation, and average milk production per month was calculated. The overall averages obtained for such animals were then ordered according to the month in the lactation period, to generate lactation curves. The recorded data used to derive total milk production per lactation and to model the shape of the lactation curve are shown in Fig 6. The data show relatively low milk production for Baladi, compared with the pure dairy breeds such as Friesians. There were only small differences in milk production among areas.

Figure 6. Average daily milk production at different lactation months of Buffaloes (B) and cross (C) breeds in the study areas (1 to 6 as in Figure 1).

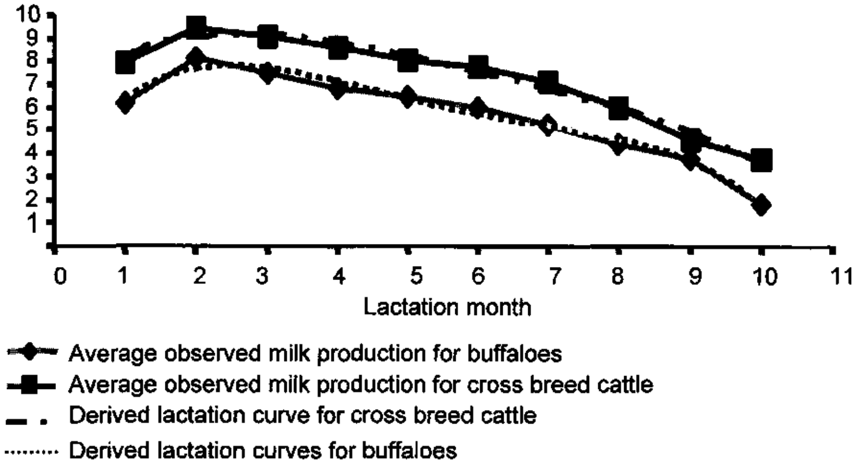


The predicted shape of the lactation curves (Figure 7) has been derived using animals from different target (study) areas. It theoretically considers milk yield under farmer conditions as consequence modified by the effects of season (Coulon et al., 1995), stage of pregnancy (Sharma et al., 1990), breed, parity number (Lescourret et al., 1994), and the dry period. The theoretical shape of the lactation curve is described by an equation that contains all above factors. In practice, the curve could adequately be described by a polynomial, based on lactation month:

$$Y_{Buffaloes} = -0.0088X^4 + 0.2007X^3 - 1.64X^2 + 4.9917X + 2.8097, \quad (R^2 = 0.9841)$$
$$Y_{Cattle} = -0.0033X^4 + 0.0823X^3 - 0.7918X^2 + 2.745X + 6.1017, \quad (R^2 = 0.9843)$$

With, Y= milk yield (litres) and X = lactation month.

Figure 7. Averaged and derived lactation for buffaloes and cross breeds



Fertility and animal health

All owners took advantage of the free vaccinations through national programs to control epidemic diseases, except for some normal pathological diseases and internal parasites. Artificial insemination (AI) is not widely implemented. However, special holders keep bulls for natural insemination and charge 7-10 LE per insemination.

Age at first calving tended to be higher, and average calving interval longer (Table 4) for buffaloes than for Baladi or crossbreeds, because their pregnancies are longer (310 days); silent heat occurs more often, calf rearing is poor, especially when milk prices are high and finally the heifer may be kept under poor feeding conditions.

Table 4. Age at first calving, average calving interval and conception rate for different breeds.

Breed	Age at first calving (months)	Calving interval (days)	Conception rate (service per insemination)
Baladi	36.00	376	0.77
Buffalo	38.52	437	0.50
Cross	33.57	408	0.61

Timing of calving

It was thought that farmers would tend to delay inseminating animals to have calves when good quality forages are available during the winter season. Data in Table 5 show that farmers are not planning calving in a particular season. Special attention was given to this point to check the validity of this statement made during interviewing by many farmers in different areas.

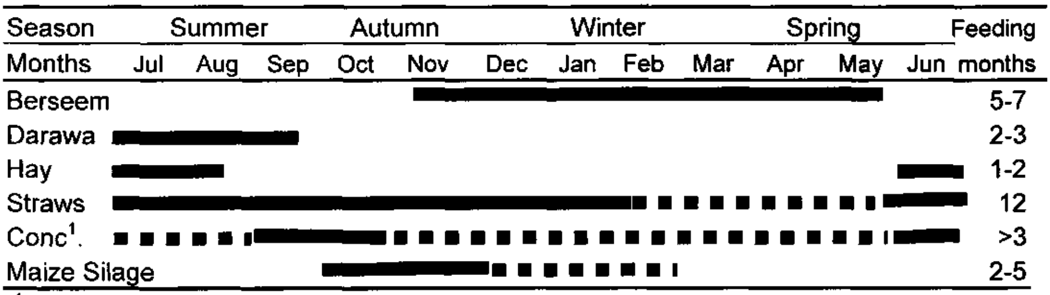
Table 5. Calving distribution throughout the year.

	Winter season							Summer season					%	
Y\M	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	W	S
1995	8	16	23	21	15	18	8	14	18	15	14	11	60.2	39.8
1996	8	23	8	24	15	7	6	14	15	6	7	6	65.5	34.5
1997	12	6	4	8	8	4	11	9	8	4	6	15	50.5	49.5
Tot.	36	45	35	53	38	29	25	36	41	25	27	32	58.7	41.3

Feeding systems

Five feeding periods/seasons have been distinguished (Figure 8) on the basis of the composition of the ration and type of feedstuffs fed to the animals. Berseem is the main green fodder and is available during the winter and spring seasons (5 to 7 months).

Figure 8. Common feeding calendar for small and medium farmers.



[1]Concentrate feed mixture

Darawa is the main fodder crop in the summer season and is available for 2-3 months. In the autumn and the transitional seasons, animals rely on berseem hay, conserved during late winter and/or spring. Straws include those of wheat, rice and broad bean are offered twice daily (morning and night) year-round, and mixed, when available, with first and/or second cut berseem at the time of feeding. In addition, small quantities of grains, cotton seed cakes (by-product of cotton oil extraction) and wheat/rice bran are also fed (some farmers also buy complete concentrate feed which is available from the market). Concentrates are mainly offered when green forages are not available or during the summer season, to alleviate the protein deficiency in the ration. In general, concentrates are only fed to cows producing above 5 liters of milk per day.

Meat production

Farmers are practicing meat production as a form of intensive use of inputs, implying a high investment rate per animal unit, such as using large amounts of concentrates to realise high growth rates over short time intervals, combined with high animal densities per unit area. Three growth stages may be distinguished in which feeding practices are adapted to match the daily gains aimed for, and that are practiced separately or sequentially:

Stage 1 (from birth to weaning). This type of veal production starts with a special calf-rearing program. The initial birth weight is around 35-38 kg for buffaloes and 25-28 kg for Baladi cattle. Farmers aim to reach 100-120 kg within a period of 90 to 100 days. Calves get initially two teats until 45 days (50% of the milk produced by their mothers), then three teats from 45 to 75 days, followed by the full udder to the end of this period. High quality concentrates (mainly wheat bran, cotton seed cake and ground maize) are used to feed the calves at a daily rate of 2% of their body weight (around 1.5 kg in the morning and 1.5 kg in the evening) at the end of the fattening period. If used at all, green forage and straws are supplied in very restricted quantities.

Stage 2 (from weaning to eight months). At this stage, farmers use weaned calves, on average starting at 100-120 kg body weight to reach 250-260 kg over a period of 6 to 8 months. The feeding systems vary strongly among regions, and in relation to type of feedstuff available and season. Berseem is the main fodder offered during winter and darawa in summer. In some areas, conserved feeds, such as maize silage are used, either with berseem in winter or in the transitional period between summer and winter seasons, when green forages are not available.

Stage 3 (from 8 to 12 months). This stage of fattening is oriented towards market demand. High quality concentrates is the main feed used. The final weight is normally around 400 kg. The feeding system is more or less the same as in stage two.

Feeds and Nutrition

Animal Unit (AU) was used to analyze the feeding situation. Dry matter (DM), Total Digestible Nutrients (TDN) and Crude Protein (CP) requirements were calculated using

NRC (1988) tables. The calculated feeding requirements per AU were 11.23, 7.06 and 1.33 kg, for DM, TDN and CP, respectively. The feeding values of the feedstuffs offered were calculated using the Egyptian feed analysis tables. Estimates of feed intake were based on quantities of feedstuffs offered minus 10% as feeding losses. Also, quantities of purchased feeds together with the production of area-cultivated fodder were compared with the quantities offered to the animals. The data were analysed to figure out the feeding situation among farm sizes, areas and years.

Figures 9, 10 and 11 present a general overview of the daily DM, TDN and CP offered and required per AU per month for all farms. It is clear that under this feeding system, the rations on offer are unbalanced all year round. A deficiency in TDN mainly occurs at the end of summer and the beginning of winter (September to February), when berseem is cultivated and still growing or during the early cuts of berseem. The CP offered tends to be close to the requirements during winter, except at the end of that season when the DM content of the fresh berseem reaches its maximum.

With regard to the size of the farms, Figures 12, 13 and 14 present average daily nutrients offered and required by size of farm and month. The figures show that the quality of the feed offered on medium-sized farms is better than that on small farms. Except at the time of cultivating berseem and during the first and second cuts (early winter), TDN were offered below requirements on small farms. Figures 15 to 20 show the variation in feeding situation among areas and years.

A general conclusion with respect to farm management on feeding is that farmers' decisions on feeding were irrational or sub optimal in the best cases, by either feeding above or below the requirements, which negatively affects dairy production and does not allow animals to express their genetic potential.

Degree of commercialization and the interaction of crop-livestock activities

The degree of commercialization tends to be quite high, for both crop and animal production. Often, one major cash crop (e.g. cotton) or vegetables are grown in combination with one or two food crops. When prices for the commercial crops are good, their area tends to expand, and when prices decrease, farmers switch to food crops (wheat-broad bean/winter and rice-maize/summer), there is some sale of surpluses and some purchase of external inputs.

The same applies to animal production. When high quality concentrates are available at reasonable prices, farmers tend to increase emphasis on fattening, compared to milk production. As soon as prices change in the opposite direction (i.e. higher prices for

Average DM, TDN and CP offered and required by month for all areas

Figure 9. Dry Matter (DM)

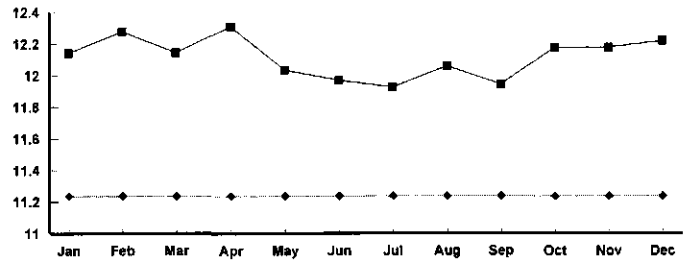


Figure 10. Total Digestible Nutrients (TDN)

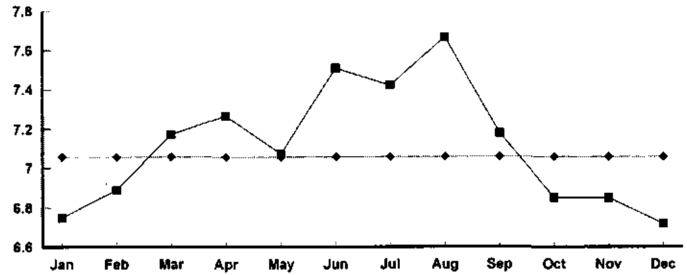
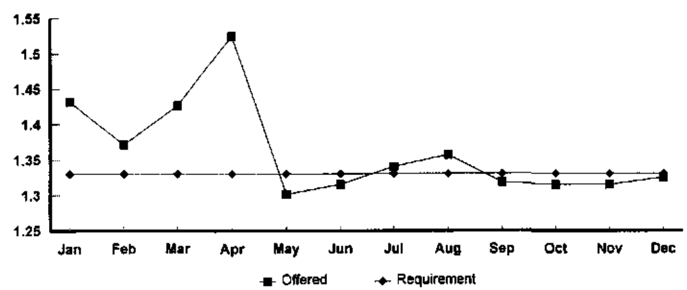


Figure 11. Crude Protein (CP)



Average DM, TDN and CP offered and required by month and year for all areas

Figure 18. Dry Matter (DM)

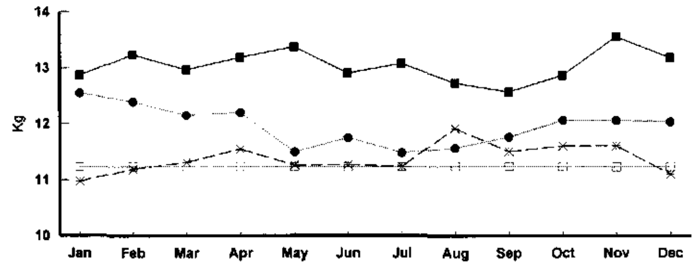


Figure 19. Total Digestible Nutrients (TDN)

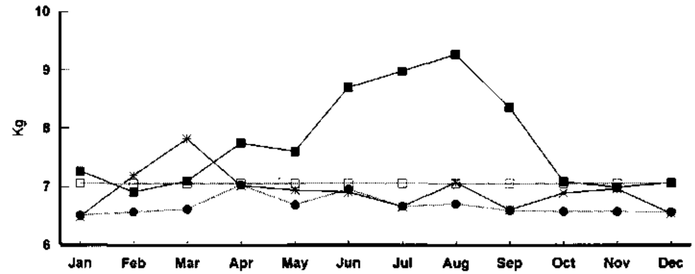
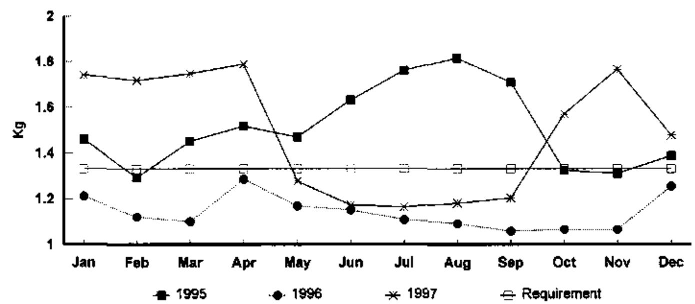


Figure 20. Crude Protein (CP)



Average DM, TDN and CP requirements and offered/AU by size of farm and month

Figure 12. Dry Matter (DM)

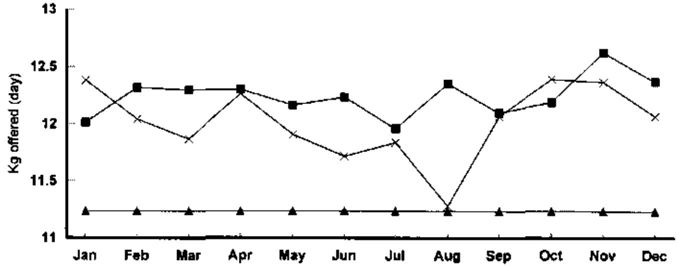


Figure 13. Total Digestible Nutrients (TDN)

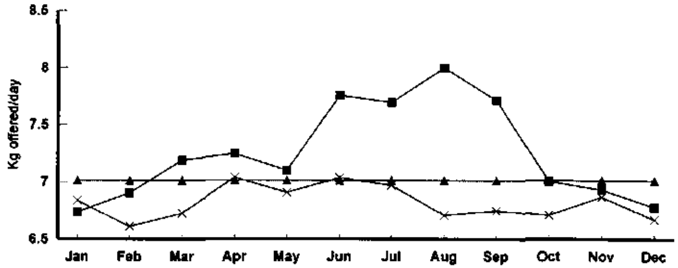
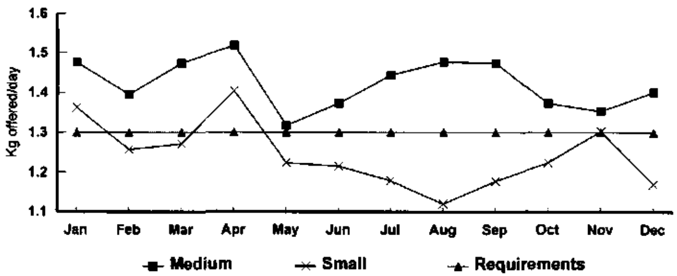


Figure 14. Crude Protein (CP)



Average DM, TDN and CP requirements and offered/AU by area and month

Figure 15. Dry Matter (DM)

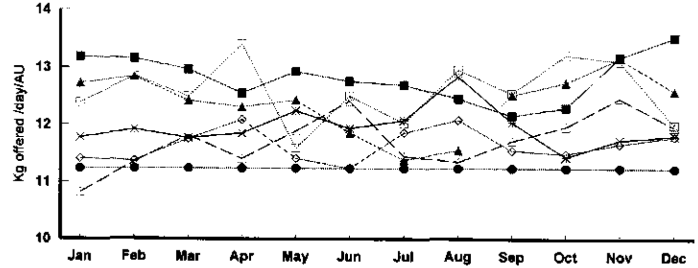


Figure 16. Total Digestible Nutrients (TDN)

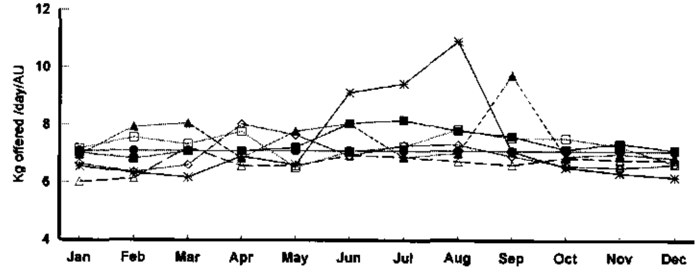
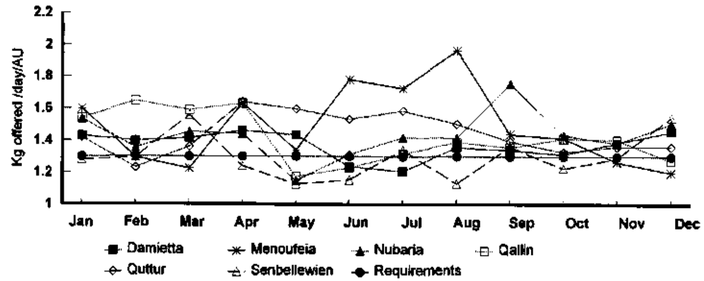


Figure 17. Crude Protein (CP)



concentrates), and fattening is commercially not attractive, farmers switch to milk production, with sale of the young male calves.
Switches between animal production and crop production also occur, when prices of animal products go up (or if they seem more profitable), farmers tend to cultivate more forage crops, at the expense of cash crops.
One of the important features of the Egyptian mixed crop-dairy farming, is that farmers can market/sell all quantities of food crops produced on the farm. That does not hold for milk production; part of the milk is processed at home to meet the family requirements for butter or cheese, part is consumed by calves and the remaining portion goes to the market. Data in Table 6 show the proportion of milk utilization.

Table 6. Proportion (%) of milk production for various purposes in the different study region.

	Ashmoun	Senbellewien	Qallin	Quttur	Nubaria	Faraskor
Home consumption	8.9	11.8	16.2	8.1	2.8	3.6
Buffalo milk for sale	57.9	66.5	26.7	11.5	39.9	15.9
Cattle milk for sale	13.9	13.9	44.1	69.8	46.0	68.1
Milk for suckling	10.4	6.6	7.5	5.6	11.2	12.1
Processed at home	8.9	1.2	5.5	5.0	0.1	0.3

A conceptual model of the farming system

One of the possibilities to study farming systems is to develop a conceptual model of the functioning of the system and to use that model to explore ways to improve the system (Shaner et al., 1981). The first stage in developing such a model is to define and represent the main components of the whole mixed crop-dairy farming system. Fig. 21 presents the main components and boundaries distinguished in this study.

In the mixed dairy farming system, three main sub-systems are distinguished:

- The household sub-system

  The household is the core of the farm unit that manages resources to undertake an integrated arrangement or pattern of crop and/or livestock activities and the allocation of resources to these activities/enterprises. The role of the household is to set priorities among the suitable crops and provide the inputs needed, including family labour, etc.
- Cropping sub-system

  This sub-system comprises two main sub-enterprises, representing the common fodder and cash crops; the main inputs come from outside the system, such as inorganic fertiliser, seeds (especially for hybrids), pesticides and extension services.

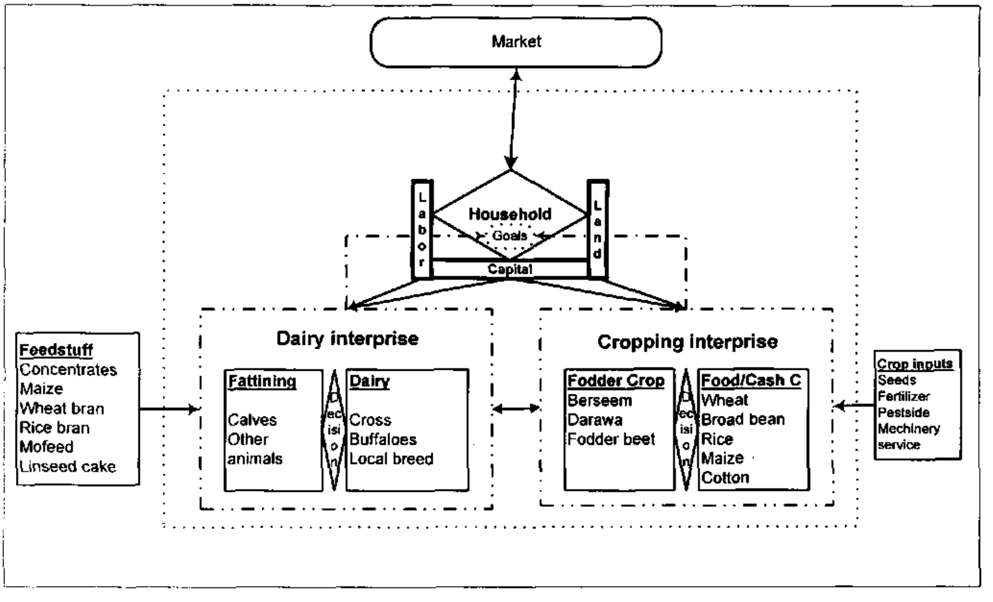
The outputs identified are grain, fodder, economic yields of cash crops and crop by-products.

- Dairy sub-system

Dairying and meat/fattening are practised combined, as one enterprise. The milk can be sold as fresh milk, mainly produced by buffaloes, or processed at home, mainly produced by cattle. Some of the milk is processed at home to make butter and cheese for home consumption. Animals for fattening originate from the calves born at the farm, purchased calves from the market and/or old animals.

Market. The boxes identified as inputs/outputs represent all purchased inputs for crops and livestock, and the products sold.

Figure 21. Schematic presentation of the mixed crop-dairy farming system.



Deriving a basis for development of a decision support system including the contributions of improved technologies and integration of crops and livestock.

On the basis of the description of the relevant sub-systems, the following specific activities were identified as necessary components of the model of the whole farming system:

- Constructing a cropping plan, taking into account the land use constraints.

- Converting the available feedstuffs into Dry Matter (DM), Total Digestible Nutrients (TDN), Crude Protein (CP) and Net Energy for Lactation (NEL).
- Deciding on possible fodder conservation and chemical treatment of crop residues, taking into account climatic conditions, suitability, feed availability, and nutrient requirements.
- Predicting animal production, milk production, body weight gain, calving.
- Estimating nutrient requirements, individually for milking animals, and by groups for other animal categories.
- Estimating quantities of feeds to be purchased to meet total animal requirements.
- Formulating least cost ration

With regard to the new technologies, it is clear that introducing improved technologies in the existing farming systems could improve the feeding situation year-round. Introducing maize and berseem silage could fill the gap between cultivation seasons. Also, introducing fodder beet as winter fodder crop could improve the balance between energy and protein in the green forage during late winter and the following transitional period. Ammonia and urea treatment could improve the poor quality straws.

Some of these activities should be optimized on the basis of availability of new technologies, or innovations in management that can improve the farming systems and allow farmers to increase revenues, compared to existing farming practices.

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Chapter 4

Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems: II Description and Implementation of the Model for Mixed Crop-Dairy Farming Systems in Lower Egypt

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(Submitted for publication)

Development of a Decision Support System for Individual Dairy Farms in Mixed Irrigated Farming Systems: II Description and implementation of the Model for Mixed Crop-Dairy Farming Systems in the Nile Delta

Summary

This paper reports on the development of a Mixed Dairy Farming Model (MDFM) that has been developed primarily for use at farm level by extension or management staff in Lower Egypt. It can be adapted for other regions. The objective of the model is to analyze present activities of a mixed farm and to maximize the profit of the farm, from both crop and dairy farming. It also allows the formulation and testing of biological parameters and management strategies at farm level to measure their impact on profit.

The model represents 365 days divided into a 12 (monthly) periods. Simultaneously it predicts animal production levels, nutrient requirements and cropping pattern based on least cost ration formulation and farm revenues.

The authors conclude that MDFM can make more efficient use and or more integration of the farm resources and improve the nutritional and economic gains significantly.

Introduction

The functioning of agricultural systems is affected by physical, biological, socio-economic and policy factors. Livestock farming is in fact an activity located at the "interface" between all of these factors and the internal processes that govern the functioning of agricultural systems, and plays a fundamental role in the equilibrium of rural societies (Vissac, 1992). The inclusion of social and economic factors, derived from survey data, into production system analysis provides a different approach from the simple integration of existing technical knowledge derived from animal production sciences.

Modelling herd performance on the basis of herd status, modified by management practices, is necessary for characterizing systems and for quantitatively estimating the effect of different technical measures affecting the herd (Beranger and Vissac, 1992). Development of models for this purpose is generally based on monitoring sample farms, including explanatory observations and discussions with farmers about their practices and concomitant appropriate recording of animal performance. The sample of farms is selected to cover a wide range of management practices, thus allowing the use of comparative analysis methods to help in the modelling process.

This paper presents a description of a model, developed as a decision support system for a mixed crop-dairy farming system, that allows for optimal farm resource use, and assessment of the impact, in nutritional and economic terms, of introducing alternative forage crops and feed resources into the system.

Model use

The Mixed Dairy Farming Model (MDFM) has been developed primarily for use at field/farm level, by extension or management staff. The model can be used as a decision support tool by the farmer, in consultation with his farm advisor, to analyze the consequences of different management strategies with respect to land use and animal nutrition, on farm profitability.

Model objectives and the objective function

The model objectives are to analyse the present activities of a mixed dairy farm from a nutritional and economic point of view, and to identify improved systems by including alternative fodder sources and feeding strategies.

MDFM is an optimisation model that maximizes net margin from farm activities, comprising total revenues from milk, animals and crops minus costs of feeding and other variable costs, such as labor, animal health care, fertiliser, etc. The net margin takes into account the opportunity costs of the resources used in dual-purpose production (e.g. maize can be produced as cash or fodder crop).

Model activities

MDFM represents 365 days, divided into 12 periods (months), starting from the day of the farm visit. The model simultaneously defines and links the following activities:

- Constructing a cropping plan, taking into account the land use constraints.
- Converting the available feedstuffs into available Dry Matter (DM), Total Digestible Nutrients (TDN), Crude Protein (CP) and Net Energy for Lactation (NEL).
- Allocating a current excess of available feed resources to fodder conservation and various feed treatments, taking into account climatic conditions, feed availability and feed requirements.
- Predicting animal performance, e.g. milk production, body weight gain and calving time.
- Estimating energy, protein, and mineral (calcium and phosphorus) requirements per individual for lactating animals and per group for other animal categories.

- Estimating the amount and type of feeds to be purchased to satisfy total herd requirements.
- Formulating a least cost ration
- Predicting farm revenues (gross or net) under the existing situation and after optimization

Model limitations

MDFM can handle only a limited number of animals, i.e. 9 milking cows, 9 milking buffaloes, 5 cattle heifers and 5 buffalo heifers, and a restricted number of types of concentrates and straws to formulate rations. The restrictions of the model are summarised in Table 1.

Table 1. Restrictions of the model by type and category

Category	Type	Limitation
Number of animals	Dairy cattle	Max. 9 milking animals
	Dairy Buffaloes	Max. 9 milking animals
	Heifers	Max. 5 heifers each (cattle/buffaloes)
	Growing /fattening animals	3 age-sex stages/groups, unlimited animal number per group
Purchased feeds	Commercial concentrates	3 types with different feeding values
	Other concentrate types	Maize, molasses, wheat/rice bran
	Straws	Wheat/rice/bean/maize
Crops	Traditional fodder crops	Berseem-darawa
	Alternative fodder crops	Fodder beet/maize for silage
	Other crops	Wheat-broad bean-maize-rice-cotton
Output	Income	Sales of milk & animals* plus cash crop revenues

* Value of total body weight gains

Model constraints

The level of intensity of the activities in MDFM is bounded by constraints imposed by the environment, time and subsystems (Gorgensen, 1994). The activities and constraints can be varied in particular runs of the model, in accordance with available resources and/or farmer decisions. The constrained operations and their limitations are shown in Table 2.

Table 2 The constraints and boundaries of the main subsystems/operations.

Operation	Identified constraints	Limitations
Land use	Cropping area per year	Two times owned land
	Cropping area and rotation	Winter = summer = owned land
Fodder conservation	Berseem silage	Produced from December to June
	Berseem hay	Produced from April to June
	Fodder beet silage	Produced from April to June
	Maize silage	Produced from September to November
Roughage treatment	Ammonia and urea treatments	Adjusted by operator or optimized
Feed availability	DM, TDN, CP	Equal or greater than requirements
Ration formulation	Molasses	Max 10% of the total DM intake
	Straw	Max 25 % of the total DM intake
	Wheat or rice bran	Max 25 % of the total DM intake
	Fresh fodder (berseem, fodder beet, darawa)	Not exceeding availability
	Maize silage	Max. 60% of the total ration (DM)
Wasted feed	Excess amount of DM to be offered	To be adjusted by operator (10% losses as default)

Model development

Cropping system

The model was designed initially to describe specifically small and medium scale mixed dairy production systems in northern Egypt, but the general structure allows easy translation to other production systems. The main characteristics of the mixed dairy production systems are that they are family-owned and operated enterprises, with various levels of capital investment. The standardized production system allows a limited number of alternative land use types under the current infrastructure, water availability, soil fertility and market conditions. These include the current (winter-summer) crop rotations: berseem-rice/berseem-cotton/ berseem-maize/wheat, broad bean-rice/wheat or broad bean-maize. Darawa (vegetative maize) or vegetables can be cultivated instead of any other crop when temperatures are suitable for sowing and/or growth.

Land use and fodder production:

Land area, crop rotation, farmer policy and environmental conditions are the main factors affecting the cropping pattern. The suitable (traditional and alternative) crops may be grown on one or two plots, to allow differences in sowing and harvesting dates, and also to differentiate productivity if different from the default/standard values given in the model.

Fodder conservation and treatments:

The model offers the possibility of making silage from maize, fodder beet, maize stover and berseem, in addition to berseem hay. The model also permits urea or ammonia treatment of straws from rice or wheat. The quantities of the various feedstuffs allocated to conservation or chemical treatment, are determined by the farmer or optimised in the model on the basis of nutritional and economic criteria.

Livestock system

The livestock system consists of a small mixed herd, comprising cattle of the local breed (Baladi), Friesian-Baladi crosses and buffaloes, adult animals and associated young stock. In some commercial/specialised enterprises e.g. 'flying herds' system (called Zarraba), male calves are normally sold at weaning or after a few days with the mother; In the model, this is left to the farmer's decision.

Herd composition:

The following classification was constructed, based on information collected on existing dairy farms:

- milking cows (females over three years old and/or with at least one parturition);
- heifers 2-3 years (females over two years old and pregnant);
- heifers 1-2 years and male animals 1-2 years;
- female calves 3-12 months;
- male calves 3-12 months;
- rearing calves (male and female) 0-3 months.

The number of animals kept on the farm depends on the farmer's attitude and his objectives with respect to herd size, defined as a function of time of the year. Sales and purchases of animals at certain ages are included to exogenously fix herd dynamics.

Herd dynamics (growth):
The herd consists of a number of animals of each of the distinguished categories. These numbers change with time - calves are born, heifers become cows and cows and heifers may be sold or may die. Changes in herd size and composition are calculated twelve times annually (monthly). Biological events such as pregnancy and delivery are tracked, to monitor the state of each individual animal in the herd. The individual characteristics distinguished for milking animals and heifers are shown in Table 3.

Table 3. State variables and their description for individual animals in the herd.

State variable	Description
Current milk production	Yield on the day of visit (kg)
Milk production potential	Expected increase in kg*
Month of lactation	Months post parturition
Pregnancy status	Pregnant or not and days post insemination
Body weight	Live body weight (kg)
Daily gain	Live body weight gain (g/d)
Fat percentage	4% for cattle and 7% for buffaloes
Parity number	Number of calving
Decision of culling	Yes or no and timing

* to be decided by farmers for pregnant heifers

Herd productivity:

Milk production: Daily milk yield is predicted from an exogenously introduced lactation curve, derived from a monitoring program of 36 farms for three years. The absolute level of production is defined by specifying the maximum attainable level, thus allowing to take into account high yielding animals (breeding) or improved environmental conditions such as housing, or offering better quality feed by the users.

Growth rate: The user can define a target daily body weight gain for each individual milking animal or per category for groups of growing animals.

Nutrient requirements:

Daily nutrient requirements for milking animals are calculated per individual, then aggregated in subgroups (e.g. milking cattle, milking buffaloes and pregnant heifers). For growing animals, requirements are calculated for one representative animal for each category and then multiplied by the total number in each category. The effects of biological characteristics, such as pregnancy and parity number are taken into account when calculating requirements. Energy, protein and mineral requirements for milk production and growth were derived from equations given in NRC (1988).

Feeding plan, monthly/daily ration:

The feed requirements of each category of animals are matched with available home-grown (fresh or conserved) and purchased feeds (Table 1). Feeding constraints (Table 2) and timing of fodder production (from the constructed cropping plan) are taken into account, and finally the economic/least cost ration is formulated.

Farm income:

MDFM takes into consideration two aspects: 1) The balance between cash payments and earnings. The expenses attributed to the sub-systems (cropping or dairy), including hired labor costs, are combined and are regarded as variable costs. In this sense, the overall cash balance represents gross margin; 2) Farm net margin, excluding off-farm income. The forage costs are based on the opportunity costs of alternative land use.

Farm economic crop products and crop residues are valued against exogenously supplied farm gate prices. The model also permits sensitivity analysis to examine the influence of changes in specific elements on farm income.

Model structure/description

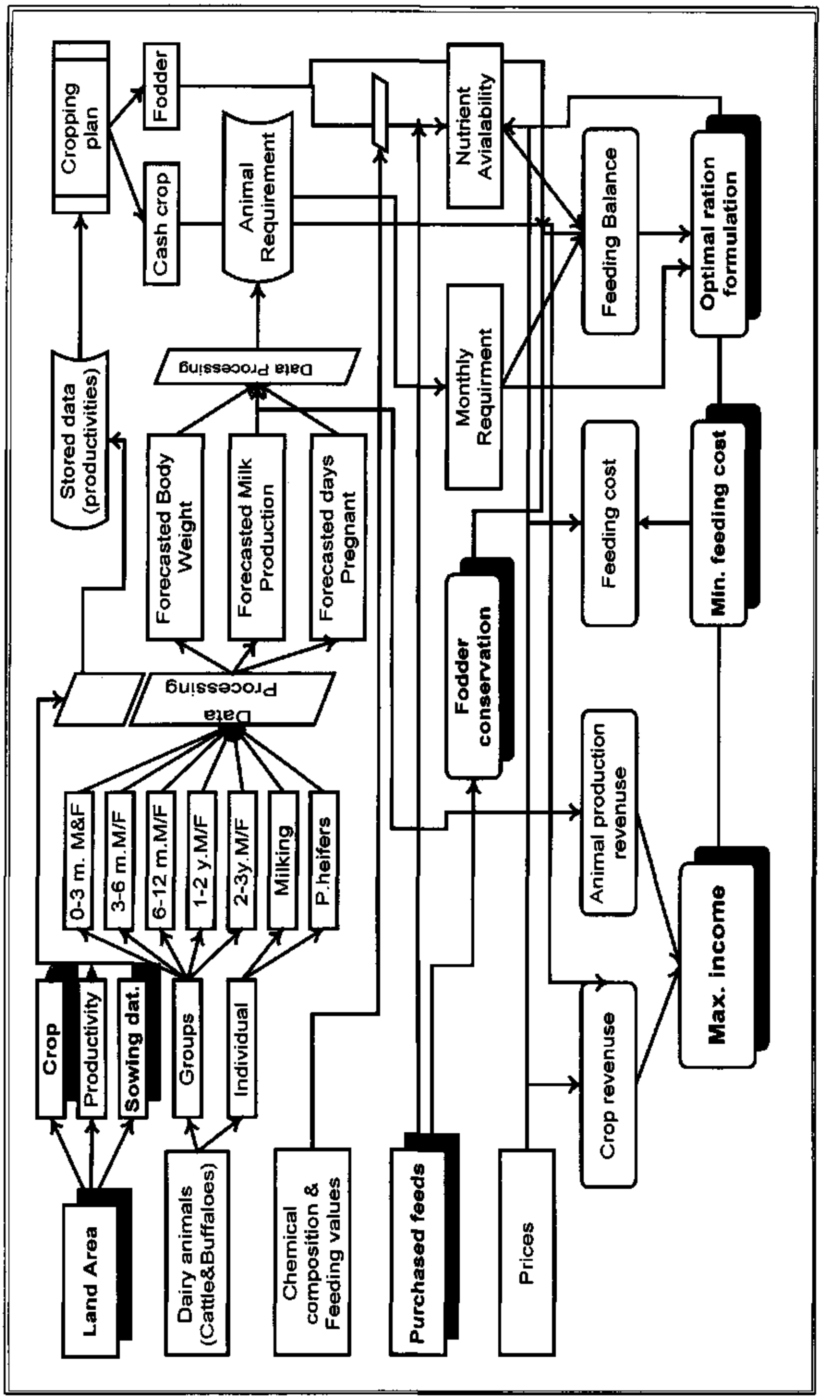
MDFM contains separate operational parts (modules), linked to simulate the whole farm. The structure of the model, including the linkages, is shown in Fig. 1.

Cropping (sub-model)

In this sub-model, crop yields are estimated, leading to estimates of availability of fresh and conserved fodder year-round. Also, the quantities of cash crop by-products are estimated in this sub-model.

Input data: A double-entry table (crop species, sowing date) was constructed, comprising yields of the most common cash and fodder crops in the region. For improved accuracy, default values for the productivity to be accepted or validated by the individual farmer, as well as a window of sowing times are provided (see Appendix 1). Productivity reference table: Data from ARC (Forage improvement project; Report on winter forage crops, November, 1989) were used to define the influence of season

Figure 1. The MDFM structure



M = Male, F = Female and P = Pregnant

Figure 2. Influence of Season on Growth Rate of Berseem in the Delt

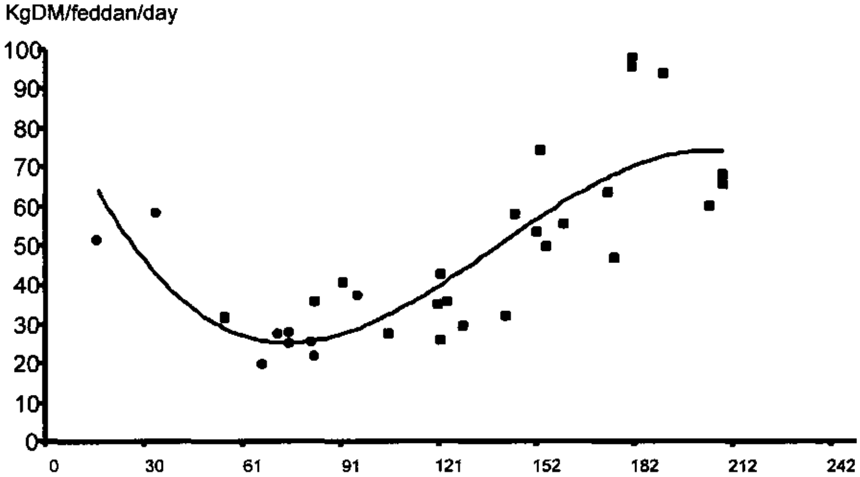
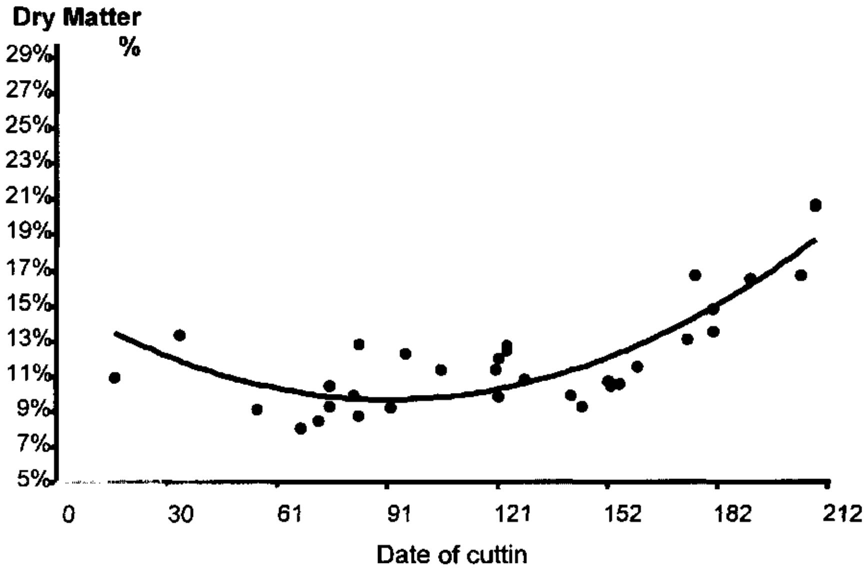


Figure3 . Influence of Season on DM % of Berseem



* Date of cutting expressed in number of days after 1st November.

on growth and dry matter content of berseem as shown in Figures 2 and 3 (FPM, 1998). This information was combined with data from the farm to derive the productivity coefficients used to generate a productivity table, that is used, in combination with cultivated area, to predict the production on a monthly basis.

Cropping plan:

The cropping plan, covering one year, starts from September[1]. For each month, information is presented on cultivated area of all crops, their production and fodder conservation, if applicable. The land area and quantities of fodder conserved are optimised, if not restricted by the farmer.

Feed and nutrient availability:

Fodder and straws produced on the farm, as well as different types of purchased concentrates (as defined by the farmer) are allocated according to the time of production. Availability can be a constraint in certain months. Chemical composition and feeding values (e.g. TDN and CP) of some feedstuffs were derived from experiments conducted by the authors; for other materials they were collected from literature.

The energy values of feedstuffs were calculated according to the following equations:

DE (Mcal/kg DM)	$= 0.441 \times TDN$	(Crampton et al., 1957)
ME (Mcal/kg DM)	$= -0.45 + 1.01DE$	(Moe and Tyrrell, 1976)
NEM (Mcal/kg DM)	$= -1.12 + 1.37ME - 0.138\,ME^2 + 0.105\,ME^3$	(Garrett, 1980)
NEG (Mcal /kg DM)	$= -1.65 + 1.42\,ME - 0.174\,ME^2 + 0.0122\,ME^3$	(Garrett, 1980)
NEL (Mcal /kg DM)	$= 0.025 \times TDN - 0.12$	(Moe and Tyrrell, 1976)

Where, TDN = Total Digestible Nutrients (%); DE = Digestible Energy; ME = Metabolizable Energy; NEM = Net Energy for Maintenance; NEG = Net Energy for Gain and NEL = Net Energy for Lactation.

Animals

In the animal sub-model, four characteristics are calculated: animal production, nutrient requirements for these animals, feedstuffs to be purchased and least cost rations for each category of animals in the herd.

Input data:

For milking animals and pregnant heifers (buffaloes and/or cattle), tables are included, containing information on individual animals (Table 3). Young and growing animals are

[1] The agricultural year starts from September

classified in age groups, as indicated earlier. The data stored per group are: number of animals, live body weight and daily weight gain. Selling or buying of animals at specific moments is entered in accordance with farmer's anticipated decisions.

State variables: This part of the model contains the state variables (status), characterizing the animals in the herd per month as the basis for estimating herd nutritional requirements: Length of pregnancy, parity number, live body weight and milk production. Length of the gestation period is assumed 280 days from conception for cattle and 310 for buffaloes. Potential milk yield increases with parity number: by 10% shifting from 1st to 2nd parity or from 2nd to 3rd parity, by 3% when shifting from 3rd to 4th parity, 2% from 4th to 5th parity; it decreases by 2% when shifting from 5th to the 6th parity (Ragab and Askr, 1958).

Monthly live bodyweight is calculated as:

$$Y = X + (G/1000)(T*30.42)$$

Where, Y= live bodyweight (kg), X = initial body weight at the start of model run (kg), G = body weight gain (g/d), T = number of months since start of the model run.

For milk production, the equations are:

$$Y = -0.0088X^4 + 0.2007X^3 - 1.64X^2 + 4.9917X + 2.8097 \text{ (for buffaloes);}$$
$$Y = -0.0033X^4 + 0.0823X^3 - 0.7918X^2 + 2.745X + 6.1017 \text{ (for cattle)}$$

Where, Y= milk yield (liters) and X = number of months since parturition

Estimating nutrient requirements:

Nutrient requirements are calculated using principles and equations from NRC (1988), with the necessary modification for use in a spreadsheet program. The equations applied to calculate energy and nutrient requirements for lactation are shown in Table 4, those for growth in Table 5. Table 6 gives the equations for predicting mineral requirements (calcium and phosphorus) for both growth and lactation.

The model calculates the requirements per individual animal, taking into account its biological state, then aggregates the nutrients required per category of animals in each month.

Nutritional/feeding balance

The assessment of feeding management practises is performed by subtracting the required nutrients from the available nutrients from cultivated fodder, crop by-products, conserved fodder and purchased feedstuffs. The balance is outlined in a graph as NE and CP.

Economic assessment

This part of the model is designed to calculate on-farm income expressed as either farm net margin or gross margin.

Farm net margin

Farm net income/earnings (NI) is defined as the production value (Y) minus production costs (X). The production costs include labor, land rent, etc. The equations used to calculate farm net margin are :

$$NI_{total} = NI_{crops} + NI_{animals}$$
$$NI_{crops} = Y_{crops} - X_{crops}$$
$$NI_{animals} = Y_{animals} - X_{animals}$$

$$Y_{crops} = \sum_{x=1}^{n} P_{crop\ x} * C_{crop\ x} * V_{crop\ x}$$

$$Y_{animals} = \sum_{x=1}^{n} P_{milk\ x} * V_{milk\ x} + LWG_{category\ x} * V_{LW\ category\ x}$$

$$X_{crops} = \sum_{x=1}^{n} CI_{crop\ x} + L_{crop\ x} + LR_{crop\ x}$$

$$X_{animals} = \sum_{x=1}^{n} FF_{crop\ x} * O_{crop\ x} + PF_{x} * V_{x}$$

Where,

P	= Productivity (ton/feddan)	C	= Cultivated area (feddan)
V	= Market price (LE)	LWG	= Live weight gain (kg)
L	= Labour cost (LE/ton)	CI	= Cultivation cost (LE)
FF	= Farm grown fodder (feddan)	LR	= Land rental (LE)
O	= Opportunity cost (LE/feddan)	PF	= Purchased feed (ton)

Gross margin

MDFM also calculates the overall cash balance (i.e. gross margin), as the balance between cash payments/expenses and cash earnings. The model takes into account only the real cash outlays associated with the sub-systems (crops and dairy) and the cash earnings from the sale of products. In this sense, fodder produced on-farm has low costs and thus leads to a reduction in the feeding costs and increased gross margin. The equations used to calculate farm gross margins are the same as for net margin with cash outlays only.

Table 4. Equations for calculating energy and nutrient requirements for lactation.

	Equation	Results
Requirements for pregnancy or lactation		
Relative metabolic body size (RELMBS)	$= LW^{0.75}/600^{0.75}$	a
Net energy for lactation in milk (NELLKG; Mcal/kg)	= 0.3512 + 0.0962 x fat %	b
Min. dietary NEL concentration for cows producing 10 kg milk	= 10 x a x (0.74/b)	c
Max.dietary NEL concentration for cows producing 40 kg milk	= 40 x a x (0.74/b)	d
Net energy concentration in dietary DM (NELDM; Mcal/kg)	=1.42+0.01((b-c)/(a x 0.74/b)) if d≥b≥c, 1.42 if b>c, 1.25 if b=0, 1.72 if b>d	e
Baseline TDN (kg) in dry matter (BTDNDM)	= (e + 0.12)/2.45	f
Energy for maintenance		
Net energy lactation for maintenance (NELM; Mcal/d)	$= 0.08 \times LW^{0.75}$ (plus 20% if the cow in 1st lact. and 20% for 2nd lact.)	g
Dry matter for maintenance (DMM; kg/d)	= g / e	h
Baseline TDN for maintenance (BTDNM; kg/d)	= h x f	i
Energy for lactation		
Net energy for lactation (NELL; Mcal/d)	= b x milk production in kg/d	j
Dry matter for lactation (DML; kg/d)	= j / e	k
Baseline TDN for lactation (BTDNL; kg/d)	= k x f	l
Energy for pregnancy (for pregnancy exceeding 210 days)		
Baseline TDN for pregnancy (BTDNP; kg/d)	$= 0.0106 \times LW^{0.75}$	m
Net energy lactation for pregnancy (NELP; Mcal/d)	$= 0.024 \times LW^{0.75}$	n
Energy for weight gain during lactation		
Baseline TDN for gain during lactation (BTDND; kg/d)	= 2.26 x daily weight gain	o
Net energy lactation for gain during lactation (NELD; Mcal/d)	= 5.12 x daily weight gain	p
Summation of energy requirement for pregnant / lactating cattle		
Baseline TDN (total) in kg/d	= i + l + m + o	
NEL (total) in Mcal/d	= g + j + n + p	

Table 5. Equations for calculating energy and nutrient requirements for growing animals

Item	Equation	Result
Maintenance		
Net energy for maintenance (NEM; Mcal/d)	$= 0.086 \times LW^{0.75}$	a.
Growth		
Net energy gain (NEG; Mcal/d) for small-breed females[1]	$= 0.045 \times LW^{0.75} (LWG/1000)^{1.119} + 1.0 \times LWG/1000$	b.
Net energy gain (NEG; Mcal/d) for small-breed males[2]	$= 0.035 \times LW^{0.75} (LWG/1000)^{1.097} + 1.0 \times LWG/1000$	c.
Feed energy concentration		
Relative body weight (RELLW)	= LW/600 (for small-breed females) and = LW/800 (for small-breed males)	d.
Metabolizable energy concentration in DM (MEDM; Mcal/kg)	=2.76 if d<0.125, 2 if d>0.750, 2.76-0.67((d-0.125)/(0.625)) if 0.750≥0.125	e.
Net energy maintenance in dietary dry matter (NEMDM; Mcal/kg)	$= 1.37 \times e - 0.138 \times e^2 + 0.0105 \times e^3 - 1.12$	f.
Net energy for growth in dietary dry matter (NEGDM; Mcal/kg)	$= 1.42 \times e - 0.174 \times e^2 + 0.0122 \times e^3 - 1.65$	g.
Dry matter (total) required (DM; kg/d)	= (a / d) + (b OR c / g)	h.
Baseline TDN (kg/d)	= (h x ((d+0.45)/1.01)/4.409	i.
Baseline TDN in DM (BTDNDM; kg)	= [(h x ((d+0.45)/1.01)/4.409]/h	j.

[1]maximum 600 kg live body weight
[2]maximum 800 kg live body weight

Table 6. Equations for calculation of calcium and phosphorus requirements for growth and lactation

State	Equation
Calcium requirements for lactation (g/d)	
If lactation number = 1	= (1.2 x 0.0154 x LW + 1.22 FCM + 0.0078 x TFG[1])/0.38
If lactation number = 2	= (1.1 x 0.0154 x LW + 1.22 FCM + 0.0078 x TFG)/0.38
If lactation number = 3	= (0.0154 x LW + 1.22 FCM + 0.0078 x TFG)/0.38
Phosphorus requirements for lactation (g/d)	
If lactation number = 1	= (1.2 x 0.0143 x LW + 0.99 x FCM + 0.0047 x TFG)/0.5
If lactation number = 2	= (1.1 x 0.0143 x LW + 0.99 x FCM + 0.0047 x TFG)/0.5
If lactation number = 3	= (0.0143 x LW + 0.99 x FCM + 0.0047 x TFG)/0.5
Calcium requirements for growth (g/d)	
If 90 ≤ live weight ≤ 250 kg	= 8.00 + 0.0367 x LW + 0.00848 x LWG
If > 250 live weight ≤ 400 kg	= 13.4 + 0.0184 x LW + 0.00717 x LWG
If live weight > 400	= 25.4 + 0.00092 x LW + 0.00361 x LWG
Phosphorus requirements for growth (g/d)	
If 90 ≤ live weight ≤ 250 kg	= 0.884 + 0.0500 x LW + 0.00486 x LWG
If > 250 live weight ≤ 400 kg	= 7.27 + 0.0215 x LW + 0.00602 x LWG
If live weight > 400	= 13.5 + 0.00207 x LW + 0.00829 x LWG

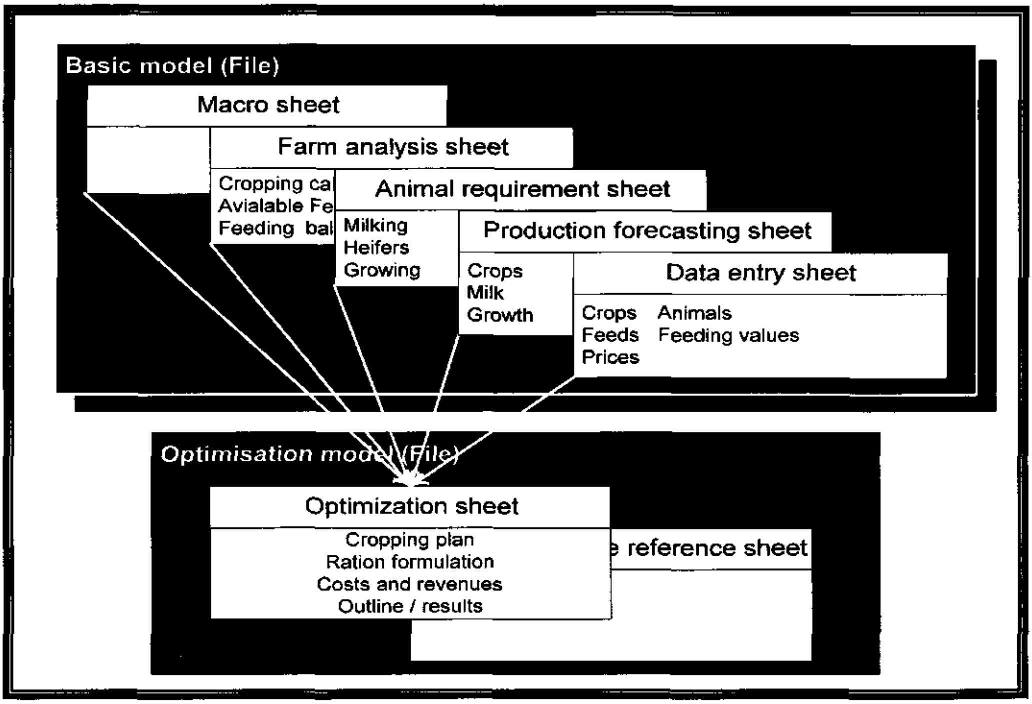
1 = total fetal gain (g/d) if pregnancy exceeds 210 days, F = 1.23 LW

Model layout

Figure 4 illustrates the MDFM layout. The model was constructed using the basic spreadsheet facilities of Lotus 1-2-3 Release 5 for Windows (Lotus Development Corporation, 1997), in combination with an optimisation program "What's Best" (Lindo System Inc., 1999). The model consists of two files (basic and optimization file): Each file contains a series of spreadsheets, each sheet for one or more particular activity(ies), as given in the model activity description. The spreadsheets are linked, if relationships between the data source sheets and calculation sheets are needed to run the model.

Macros are extensively used to allocate and store calculated data and for printing the results.

Figure 4. MDFM layout



Model calculations

The following example illustrates a typical run of MDFM. The activity definitions used for the model runs have been presented earlier. A brief explanation of the activities engaged in at the farm, and included in the model calculations is provided below.

Land use

Table 7 shows the crop-input data required for running MDFM. The existing structure provides list of cash and fodder crops, allows farmers to select the suitable crops and decide the sowing month. Default values for sowing months, crop area and productivities are provided, and will be selected, unless specified exogenously by the model user and/or the operator. The model also allows cultivation of one crop on two separate plots of land with different cultivation characteristics.

Table 7. Input data for land use

Crop[1]	Crop selection and cultivation months			Area		Prod.[3]
	Sowing month	Default	Limitation	Restricted[2]	Optimized	Default
rseem (long term)	September	Sep	Sep - Nov	No	0	40
Broad bean (late)	November	Sep	Sep - Nov	No	0	14
Maize (for silage)	May	Nov	Nov - Dec	No	0	20
Rice	June	Dec	Nov - Dec	No	0	6

[1] A complete list of crops is provided in Appendix 1
[2] MDFM user can select an area for each crop, otherwise the model will optimize the area
[3] Productivity (ton/feddan, as it is)

The herd

The herd consists of two breed (buffaloes and cattle); the animals per breed are divided in two groups (growing animals and lactating animals. Each group of animals is divided in different categories, on the basis of age: heifers 1-2 years; male animals 1-2 years; female calves 3-12 months; male calves 3-12 months; and rearing calves (male and female) 0-3 months. This classification is based on information collected in farm surveys. Farmers tend to distinguish these categories because they aim at different growth rates for each category, which may guide selection of the quality of feedstuffs offered to animals. Table 8 shows the input data required per breed and category of animals.

Table 8. Input data for growing animals (summary[1])

	Cattle			Buffaloes		
	No.	B[2] weight (kg)	Daily gain (g)	No.	B[2]. weight (kg)	Daily gain (g)
Heifer 1-2 years	4	250	150	2	300	120
Male 3-12 m.	6	105	400	4	160	650
Female 3-12 m.	4	110	700	3	140	320
Calves 0-3 m.	2	70	500	2	90	200

[1] The detailed input data for growing animal are provided in Appendix 1
[2] B is live body, [3] m is age of animal per month

For dairy cows and pregnant heifers, a set of data is required per individual animal per breed as shown in Table 9. The number of dairy animals is restricted to maximum 9 milking animals and 5 pregnant heifers per breed. In practice, this number of dairy animals is not a real limitation of the model, considering the size of farm holdings (small and medium) in Egypt. The input data take into consideration biological changes in the animals that may affect the nutritional requirements in the future. However, the above data are necessary to predict actual nutritional requirements, that meet the biological needs of the animals.

Table 9. Input data for dairy animals[1]

	Daily Milk production (litre)	Lactation month	Days pregnant	Body weight (kg)	Daily gain (g)	Fat (%)	Lactation number
Cattle (cows)	15	3	35	434	17	4	3
Buffaloes (cows)	8.5	5	95	438	42	7	4
Heifers (cattle)	14.5	1	260	388	51	4	1
Heifers (buffaloes)	7.5	1	285	380	100	7	1

[1] Average per category, detailed data are provided in Appendix 1

Other input data

The feeding values of feedstuffs, market prices of milk, meat, cash crops and amount of concentrates that can be purchased by farmers should be provided endogenously or exogenously as applying to the farm area under consideration. Table 10 provides an example of the required data.

Table 10. Input data of feeding values, market prices and purchased concentrates[1]

	Feeding values (%)		Market price	Purchased
	TDN[2]	CP[3]	(LE)	amount (tons)
Berseem	58.7	17.4	300	---
Wheat bran	68.0	16.3	700	5
Rice straw	42.9	5.2	45	20
Bean straw	51.0	7.5	150	---
Maize silage	69.9	9.3	250	---
Concentrate	69.3	16.8	670	10

[1] Example of the feedstuff used in ration formulation only, a complete list of feedstuffs is provided in Appendix 1, [2] Total Digestible Nutrients, [3] Crude Protein

Model calculation/predicted output

Land use, crop production and fodder conservation

Table 11 illustrates the results of an MDFM model run for optimal cropping areas that result in maximum income from the whole farm enterprise. Model results suggest that the combination of berseem long term (fodder crop) and broad bean (cash crop) is the optimal winter cropping pattern, followed by rice (cash crop) and maize for silage as summer crops. Indeed, this pattern is typical for the situation where water availability allows rice cultivation.

Table 11. MDFM output of land use, crop production and fodder conservation

Crop	Area (feddan)	Sowing Month	Main-product[1]	By-product[1]	Conservation Hay[1]	Conservation Silage[1]
Berseem (long-term)	25.4	September	93.28	---	---	70.84
Broad bean (late)	4.6	November	5.49	4.57[2]	---	---
Maize (for silage)	8.3	May	---	---	---	33.34
Rice (field 1)	21.7	June	129.99	21.67[2]	---	---

[1] per ton fresh matter
[2] per ton fresh matter

Prediction of milk production and body weight

MDFM predicts milk production for each individual animal for 365 days (12 periods) using a standard lactation curve for each breed (Chapter 4). The shape of the lactation curve was developed on the basis of results of on-farm monitoring for three consecutive years. The actual lactation curves used, are influenced by pregnancy status and (exogenously supplied) maximum daily milk production. For local breeds, animals are set 'dry' if milk production drops below 2 litre per day; maximum lactation length is set to 10 months, if animals get pregnant. Milk production can be extended up to 12 months, if animals are not pregnant and still producing significant amounts of milk. The same rules apply for pregnant heifers. For body weight changes, a comeulative body weight function is applied, containing month since monitoring, initial body weight and daily gain as supplied by the user farmer. A detailed table of predicted milk production and body weight is provided in Appendix 1.

Prediction of nutrient requirements

The model calculates the requirements for an individual animal, according to its biological state, then aggregates the nutrients required per category of animals in each month. Different equations are applied to calculate the nutrient requirements for lactating and growing animals. The model predicts energy, protein and mineral (calcium and phosphorus) requirements in different unit's e.g. g/kg DM, Mcal and/or proportions in DM requirement. Table 12 compares the predicted nutritional requirements for various biological status using MDFM with those given by NRC (1988). The values are in close agreement, except for CP, where the difference was ± 1% . The reason could be that NRC has limitations for live body weight (minimum 400kg) and fat percentage (maximum 5.5%). In MDFM such limitations have not been introduced, which means that MDFM is more suitable for buffaloes and breeds of small size.

Table 12. Nutritional requirements for various biological status as predicted by NRC (1988) and MDFM

Items	Values									
	NRC	MDFM	NRC	MDFM	NRC	MDFM	NRC	MDFM	NRC	MDFM
Animal status										
Milk production (litre)	5	5	10	10	15	15	20	20	25	25
Lactation month	2	2	3	3	4	4	6	6	8	8
Days pregnant	30	30	60	60	90	90	225	225	260	260
Body weight (kg)	400	400	400	400	420	420	480	480	550	550
Daily gain (g)	200	200	150	150	100	100	50	50	0	0
Fat (%)	3.7	3.7	4	4	4	4	4	4	4	4
Lactation number	1	1	2	2	3	3	3	3	3	3
Predicted nutrient requirements										
DM (kg)	9.26	9.26	11	11	12.5	12.53	14.91	14.91	17.34	17.34
NEL (Mcal)	13.15	13.15	16	16	18.9	18.97	23.18	23.18	27.49	27.49
CP (g)	1037	1203	1523	1549	1930	1867	2352	2283	2771	2879
Ca (g)	34.78	34.78	49.9	49.94	65.2	65.2	83.7	83.7	102.6	102.6
P (g)	23.18	23.18	32.4	32.38	41.7	41.7	53.3	53.3	65.2	65.2
TDN (kg)	5.82	5.82	7.07	7.07	8.36	8.36	10.19	10.19	12.07	12.07
ME (Mcal)	21.76	22.05	26.54	26.75	31.59	31.59	38.68	38.75	45.94	45.94
DE (Mcal)	25.65	25.65	31.16	31.16	36.85	36.85	44.93	44.94	53.21	53.21

Nutrient/feeding balance

Feeding management practises are assessed by subtracting the required nutrients from the nutrients available from cultivated fodder, crop by-products, and conserved fodder and purchased feedstuffs. The predicted feeding situation is presented in the model in graph, indicating the deficiency of nutrient availability in certain month. As for nutrient requirements, availability of nutrients is calculated per month, because the use of feed balances as annual aggregates is misleading, as seasonal peaks in demand and/or supply cannot be accommodated. Aggregation of feeds and requirements also excludes the possibility of selective consumption, i.e. instead of trying to utilise all feeds, it may be advantageous not to utilise part of the (low quality) feed resources. Moreover, an aggregate feed balance may mask a protein or energy excess in one animal category, with a deficiency in another.

Least cost ration formulation

Model calculations aim at minimizing the feeding costs, while meeting the nutritional requirements of each category of animals with feed available from the own farm (fresh or conserved) and purchased feeds, taking into account the feeding constraints and time pattern of fodder production. Table 13 provides an example of a least cost ration for one category (dairy cows).

The prices of the forages are calculated as the direct costs of fodder production, while for concentrates and rice straw, the market prices were used. The nutritional constraints require that optimal diets satisfy animal requirements for dry matter, energy and protein. In addition, constraints specify a maximum proportion (in terms of dry matter) of specific feedstuffs in the formulated ration (see Table 2, Chapter 4).

Table 13. Calculated least cost ration for dairy cows[1]

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Feedstuff (kg)												
Berseem	---	---	6322	6240	6443	6628	6495	5588	4810	1653	---	---
Rice straw	---	---	---	---	---	---	---	523	888	397	---	---
Bean straw	---	---	---	---	---	---	---	---	---	277	---	1062
Maize silage	4080	4261	1444	1471	1194	737	370	---	---	2792	2390	2316
Concentrate 3	1530	3509	---	---	---	---	---	---	---	---	---	249
Corn	---	---	---	---	---	---	---	---	---	---	1096	46
Wheat bran	1870	42	---	---	---	---	---	---	---	---	896	574
Nutrient availability (kg)												
DM[2]	7479	7812	7766	7711	7636	7365	6865	6111	5697	5120	4382	4247
TDN[3]	5183	5438	4720	4691	4616	4406	4071	3504	3204	3234	3156	2760
CP[4]	941	993	1234	1223	1232	1222	1165	999	883	589	461	434

[1] Dairy cows only; results for the other categories are presented in Appendix 1
[2] Dry Matter (including 10% feeding losses)
[3] Total Digestible Nutrients
[4] Crude Protein

The formulated ration satisfies the nutrient requirements for each category of animals plus 10 percent losses during feeding. The ration ingredients match with the temporal pattern of fodder production and availability, e.g. berseem cultivation starts in September and becomes available for feeding (first cut 45-60 days after sowing, Chapter 3) in November. Similarly, bean and rice straws become available for feeding after harvesting. Purchased feedstuffs, can be fed any time of the year.

Table 14 represents the feeding costs per category of feeds and animals. The feeding costs per category of feed represent the cash requirements at a certain time, when referring to external inputs. The costs per category of animals indicate the relative costs for each category, which allows farmers to compare costs and revenues per category of animals.

Table 14. Feeding cost (LE) per feed component and animal category

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Feed component												
Fresh forage	0	0	1958	1994	2092	2182	2223	2082	1949	1375	0	0
Straws	36	126	8	10	13	18	23	52	75	104	157	326
Conserved forage	1138	1218	355	339	271	173	91	12	6	559	1172	1195
Concentrates	3370	3069	274	119	147	179	268	236	203	283	2826	2228
Animal Categories												
Milking cows	3131	3212	1589	1577	1565	1514	1415	1178	1034	946	1751	1208
Heifers 1-2 years	317	303	197	200	203	206	209	215	221	227	448	480
Males 6-12 months	465	355	283	308	328	341	354	366	377	379	757	806
Females 6-12 months	210	150	116	124	131	138	146	151	155	159	283	294
Males 3-6 months	119	89	70	77	84	90	97	104	112	119	208	210
Females 3-6 months	50	54	43	47	51	55	60	64	67	70	119	129
Calves 0-3 months	252	249	296	128	162	207	325	303	268	421	591	620
Total feeding costs	4544	4412	2595	2461	2523	2552	2606	2382	2233	2321	4155	3748

Farm economics

Table 15 presents the gross value of crop and animal production and their costs over one year.

Table 15. Gross margin of the crop-dairy farm over one year

	Production cost	Production values	Gross margin
Cash crops			
Broad bean	3204	3479	275
Rice	19499	81245	61746
Subtotal	22703	84723	62021
Animal products			
Milk	20165	25112	4948
Weight gain	16306	54973	38667
Subtotal	36471	80086	43615
Total	59174	164809	105635

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Appendix

Table 1. Input table for land use

Crop	Crop selection and cultivation months			Area		Prod. Default *
	Sowing month	Default	Limitation	Restricted[3]	Optimized	
Berseem (long term)	Month/default	Sep	Sep -- Nov	Yes/No	Value / 0	40
Berseem (short term)	Month/default	Sep	Sep -- Nov	Yes/No	Value / 0	14
Wheat area 1	Month/default	Nov	Nov -- Dec	Yes/No	Value / 0	15
Wheat area 2	Month/default	Dec	Nov -- Dec	Yes/No	Value / 0	13
Broad bean early	Month/default	Nov	Nov -- Dec	Yes/No	Value / 0	1.2
Broad bean late	Month/default	Dec	Nov -- Dec	Yes/No	Value / 0	1.0
Darawa area 1	Month/default	Mar	Mar -- Sep	Yes/No	Value / 0	15
Darawa area 2	Month/default	Apr	Mar -- Sep	Yes/No	Value / 0	15
Fodder beat1[1]	Month/default	Sep	Sep -- Nov	Yes/No	Value / 0	50
Fodder beat 2[2]	Month/default	Dec	Dec -- Feb	Yes/No	Value / 0	40
Maize (duel purpose)	Month/default	May	May -- Jul	Yes/No	Value / 0	3
Maize (for silage)	Month/default	May	May -- Jul	Yes/No	Value / 0	20
Rice (field 1)	Month/default	May	Jun -- Jul	Yes/No	Value / 0	6
Rice (field 2)	Month/default	Jun	Jun -- Jul	Yes/No	Value / 0	6
Cotton	Month/default	Mar	Mar -- Apr	Yes/No	Value / 0	0.7

* Default values of productivity per ton (fresh matter for fodder crop and air dry for cash crop) per feddan [to be used if confirmed by farmers, changed in case if it differs than farmer productivity].

1 Fodder beat cultivated by seeding

2 Fodder beat cultivated by transplanting

3 MDFM allow the users to define area per crop without optimization

Table 2 Input data of the growing animals per category and breed

	Cattle			Buffaloes		
	Number	Body weight	Daily gain	Number	Body weight	Daily gain
Heifer (2-3 years)	2	350	150	2	350	150
Heifer (1-2 years)	4	250	400	2	300	120
Male calves 6-12 months	4	200	800	3	200	800
Female calves 6-12 months	3	120	500	2	180	150
Male calves 3-6 months	2	110	650	1	120	500
Female calves 3-6 months	1	100	500	1	100	500
Calves 0-3 months	2	70	500	2	90	200

Table 3. Input data of the dairy cows/heifers status at the day of visit

	Milk production	Lactation month	Days pregnant	Body weight	Daily gain	Fat percentage	Lactation number
Cattle (cows)							
Cow1	10	6	120	550	1	4	3
Cow2	11	5	90	400	50	4	2
Cow3	12	4	90	420	50	4	1
Cow4	14	2	15	520	1	4	4
Cow5	25	1	0	400	50	4	4
Cow6	12.5	4	0	400	1	4	4
Cow7	13.5	2	0	450	1	4	4
Cow8	17	4	0	350	1	4	4
Cow9	20	2	0	420	1	4	3
Buffaloes (cows)							
Cow1	6	7	180	420	50	7	4
Cow2	7	6	120	480	20	7	4
Cow3	10	4	70	400	50	7	4
Cow4	11	2	10	450	50	7	4
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
Dry cow, heifers pregnant (cattle)							
Heifer 1	14	1	270	390	100	4	1
Heifer 1	17	1	260	380	100	4	1
Heifer 2	12	1	270	380	1	4	1
Heifer 3	15	1	240	400	1	4	1
Heifer 4	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
Dry cow, heifers pregnant (buffaloes)							
Heifer 1	8	1	290	390	100	7	1
Heifer 1	7	1	280	370	100	7	1
Heifer 2	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0
x	0	0	0	0	0	0	0

Table 4. Input data of product prices and production cost per feddan

	Unit	Farm gate price	Production cost
Cash crops			
Wheat	Ardab	80	500
Field bean	Ardab	95	700
Maize	Ardab	65	800
Rice	Darepa	250	900
Cotton	Qentar	400	800
Animal products			
Milk (buffaloes)	liter	1.2	
Milk (cattle)	liter	1	
Standing weight (adult)	kilo	6	
Standing weight (growing)	kilo	8	

Table 5. Input data of feeding values, market prices and purchased feedstuff

Feedstuff	Feeding values		Market	Purchased
	TDN	CP	price	Amount
Berseem	58.7%	17.4%	300	---
Darawa	66.5%	4.7%	250	---
Fodder beat	75.0%	9.7%	150	---
Corn stalk	35.0%	5.0%	30	0
Wheat straw	32.0%	4.7%	150	0
Rice straw	42.9%	5.2%	45	20
Bean straw	51.0%	7.5%	150	0
Maize silage	69.9%	9.3%	250	---
Fodder b. Silage	70.0%	10.0%	300	---
Corn stover silage	55.0%	6.5%	65	---
Clover hay	52.0%	12.5%	350	---
Ammoniated corn stalk	62.0%	8.9%	45	---
Ammoniated rice straw	50.0%	7.1%	55	---
Ureated corn stalk	50.0%	11.0%	60	---
Ureated rice straw	45.0%	8.7%	60	---
Concentrate 1	60.0%	12.0%	460	0
Concentrate 2	65.0%	14.0%	550	0
Concentrate 3	69.3%	16.8%	670	10
Corn	80.0%	8.5%	600	5
Wheat bran	68.0%	16.3%	700	5
Rice bran	63.2%	15.6%	450	0
Mofeed	80.0%	8.0%	350	0
Berseem silage	55.0%	15.0%	220	---

Table 6. Model output of cropping plan, production and fodder conservation

Crop	Area (feddan)	Sowing month	Main product	By-product	conservation Hay	silage
Berseem long	25.8	Sep	94.6	0	0	71.7
Berseem short	0	0	0	0	0	0
Wheat early	0	0	0	0	0	0
Wheat late	0	0	0	0	0	0
Broad bean early	4.2	Nov	5.1	4.2	0	0
Broad bean late	0	0	0	0	0	0
Darawa area 1	0	0	0	0	0	0
Darawa area 2	0	0	0	0	0	0
Fodder beat (by seeds)	0	0	0	0	0	0
Fodder beat (with transplanting)	0	0	0	0	0	0
Maize (duel purpose)	0	0	0	0	0	0
Maize (for silage)	8.3	May	0	0	0	33.1
Rice (field 1)	0	0	0	0	0	0
Rice (field 2)	21.7	Jul	130.6	21.7	0	0
Cotton	0	0	0	0	0	0
Land use(2season)	30					

Table 7. Predicted Milk Production for cattle's and buffaloes

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	Body weight	
Cattle (cows)												Milk	initial	final
Cow 1	10	9.1	7.8	7.2	5.8	0.0	0.0	0.0	0.0	0.0	0.0	1196	550	550.3
Cow 2	11	10.2	10.0	9.1	7.8	7.2	5.8	0.0	0.0	0.0	0.0	1830	400	416.5
Cow 3	12	11.2	10.9	9.9	8.5	7.8	6.3	0.0	0.0	0.0	0.0	1996	420	436.5
Cow 4	14	13.6	12.8	11.9	11.6	10.6	9.1	8.3	6.7	0.0	0.0	2957	520	520.3
Cow 5	25	29.4	28.4	26.9	25.0	24.4	22.2	19.1	17.5	14.1	0.0	6956	400	416.5
Cow 6	12.5	11.6	11.3	10.3	8.9	8.1	6.5	0.0	0.0	14.1	0.0	2501	400	400.3
Cow 7	13.5	13.1	12.4	11.5	11.2	10.2	8.8	8.0	6.5	0.0	0.0	2852	450	450.3
Cow 8	17.0	15.8	15.4	14.0	12.1	11.1	8.9	0.0	0.0	0.0	0.0	2828	350	350.3
Cow 9	20.0	19.4	18.3	17.0	16.6	15.1	13.0	11.9	9.6	0.0	0.0	4225	420	420.3
Buffaloes (cows)														
Cow 1	6.0	5.2	4.7	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	591	420.0	436.5
Cow 2	7.0	6.4	5.5	5.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	837	480.0	486.6
Cow 3	10.0	9.3	9.1	8.3	7.1	6.5	5.2	0.0	0.0	0.0	0.0	1664	400.0	416.5
Cow 4	11.0	10.6	10.1	9.4	9.1	8.3	7.1	6.6	5.3	0.0	0.0	2324	450.0	466.5
Cow 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cow 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cow 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cow 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cow 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Pregnant heifers (cattle)														
Heif. 1	14.0	16.5	18.7	20.1	20.1	19.6	17.4	13.3	9.3	5.2	0.0	0.0	390.0	423.0
Heif. 2	17.0	20.0	22.7	24.4	24.4	23.8	21.1	16.1	11.3	6.3	0.0	0.0	380.0	413.0
Heif. 3	12.0	14.1	16.0	17.2	17.2	16.8	14.9	11.4	8.0	4.5	0.0	0.0	380.0	380.3
Heif. 4	0.0	15.0	17.6	20.0	21.6	21.6	21.0	18.6	14.2	10.0	5.6	0.0	400.0	400.3
Heif. 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pregnant heifers (buffaloes)														
Heif. 1	0.0	8.0	9.4	10.7	11.5	11.5	11.2	9.9	7.6	5.3	3.0	0.0	390.0	423.0
Heif. 2	0.0	7.0	8.2	9.4	10.1	10.1	9.8	8.7	6.6	4.6	2.6	0.0	370.0	403.0
Heif. 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heif. 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heif. 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8. Predicted nutrient requirements for different categories of animals

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dairy cows and pregnant heifers												
DM	6799	7101	7060	7010	6942	6695	6241	5555	5179	4654	3983	3861
TDN	4441	4730	4720	4691	4616	4406	4071	3504	3204	2803	2282	2159
CP	997	1061	1050	1049	1034	978	892	759	687	589	461	434
Heifers (1-2 years)												
DM	926	960	995	1031	1068	1106	1144	1184	1225	1267	1311	1355
TDN	578	596	614	632	651	669	688	708	727	747	768	789
CP	111	115	119	124	128	133	137	142	147	152	157	163
Male (6-12 months)												
DM	1046	1148	1251	1358	1467	1580	1697	1819	1945	2077	2216	2361
TDN	701	761	821	881	941	1003	1065	1128	1192	1258	1326	1396
CP	154	162	170	178	187	195	204	218	233	249	266	283
Female (6-12 months)												
DM	456	486	517	547	578	610	643	676	709	744	780	816
TDN	307	325	343	361	379	398	416	434	452	471	489	508
CP	69	72	74	76	78	81	83	85	88	90	94	98
Male (3-6 months)												
DM	258	287	316	344	373	402	432	462	492	523	555	588
TDN	180	198	216	234	252	269	287	304	321	339	356	374
CP	46	49	51	53	56	58	60	63	65	67	70	72
Female (3-6 months)												
DM	158	175	193	210	228	245	264	282	301	321	341	361
TDN	109	120	131	141	152	162	173	183	193	204	215	226
CP	28	29	30	32	33	34	36	37	39	40	41	43
Calves (0-3 months)												
DM	505	560	614	266	340	458	755	741	668	1143	1210	1277
TDN	354	393	430	186	237	317	519	506	454	768	808	847
CP	105	110	115	49	61	78	124	117	103	167	172	177

Table 9.1 least cost ration formulation for dairy cows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	6443	6628	6495	6111	5697	1704	0.0	0.0	0.0	0.0	6321	6240
Darawa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fodder beat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corn stalk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat straw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice straw	0.0	0.0	0.0	0.0	0.0	622	0.0	0.0	0.0	0.0	0.0	0.0
Bean straw	0.0	0.0	0.0	0.0	0.0	0.0	7.9	1062	1529	0.0	0.0	0.0
Maize silage	1194	737	369	0.0	0.0	2793	2390	2316	4079	4261	1444	1471
F. beat silage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stover silage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Berseem silage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clover hay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ammoniated stalk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ammoniated straw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ureated m. stalk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ureated r. straw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Concentrate 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Concentrate 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Concentrate 3	0.0	0.0	0.0	0.0	0.0	0.0	843	788.0	0.0	3177	0.0	0.0
Corn	0.0	0.0	0.0	0.0	0.0	0.0	1141	80.7	0.0	0.0	0.0	0.0
Wheat bran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1869	374	0.0	0.0
Rice bran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mofeed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nutrients availability (kg)												
DM (+10%)	7636	7364	6864	6111	5697	5119	4381	4246	7479	7811	7766	7711
TDN	4616	4405	4071	3587	3344	3219	3171	2771	4903	5434	4720	4691
CP	1232	1222	1164	1063	991	588	461	434	798	991	1234	1222

Table 9.2 least cost ration formulation for heifers aged 1-2 years

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	928	934	944	977	1011	1045	0	0	0	0	912	921
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	246	282	315	326	337	348	0	0	0	0	183	213
Bean straw	0	0	0	0	0	0	0	269	182	204	0	0
Maize silage	0	0	0	0	0	0	786	813	555	576	0	0
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	0	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	0	0	4	36	27	276	0	0
Corn	0	0	0	0	0	0	291	0	0	0	0	0
Wheat bran	0	0	0	0	0	0	360	373	255	0	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Nutrients availability (kg)												
DM (+10%)	1175	1216	1259	1302	1347	1394	1442	1491	1018	1056	1095	1134
TDN	651	669	689	713	738	763	1030	984	672	698	614	632
CP	174	177	181	187	193	200	157	163	111	115	168	171

Table 9.3 least cost ration formulation for male calves aged 6-12 months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	1614	1626	1813	1921	2031	1653	0	0	0	0	1260	1455
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	0	113	0	0	0	571	0	0	0	0	0	0
Bean straw	0	0	0	0	0	0	439	0	0	0	0	0
Maize silage	0	0	0	0	0	61	1330	1417	527	662	116	39
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	26	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	0	0	60	617	624	574	0	0
Corn	0	0	0	0	0	0	0	563	0	0	0	0
Wheat bran	0	0	0	0	0	0	609	0	0	0	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Nutrients availability (kg)												
DM (+10%)	1614	1738	1813	1921	2031	2285	2437	2597	1151	1262	1377	1494
TDN	947	1003	1065	1128	1192	1258	1609	1869	801	875	821	881
CP	281	289	316	334	353	323	266	283	154	162	230	257

Table 9.4 least cost ration formulation for female calves aged 6-12 months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	583	640	700	728	780	818	0	0	0	0	481	530
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	0	0	0	15	0	0	0	0	0	0	0	0
Bean straw	0	0	0	0	0	0	147	0	0	0	0	0
Maize silage	53	31	7	0	0	0	468	490	201	233	88	72
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	45	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	0	0	28	8	301	256	0	0
Corn	0	0	0	0	0	0	0	176	0	0	0	0
Wheat bran	0	0	0	0	0	0	214	224	0	0	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Nutrients availability (kg)												
DM (+10%)	636	671	707	743	780	818	858	898	502	535	568	602
TDN	379	398	416	434	458	480	567	641	349	366	343	361
CP	106	114	122	127	136	142	94	98	69	72	92	99

Table 9.5 least cost ration formulation for male calves aged 3-6 months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	313	357	405	455	509	567	0	0	0	0	234	272
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	0	0	0	0	0	0	0	0	0	0	0	0
Bean straw	0	0	0	0	0	0	0	98	0	65	0	0
Maize silage	97	85	70	53	32	8	333	353	155	172	113	107
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	0	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	0	0	0	35	0	0	0	0
Corn	0	0	0	0	0	0	189	0	58	0	0	0
Wheat bran	0	0	0	0	0	0	89	162	71	79	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Nutrients availability (kg)												
DM (+10%)	410	443	475	508	541	576	611	646	284	316	347	379
TDN	252	269	287	304	321	339	444	430	203	207	216	234
CP	64	70	77	84	92	99	62	72	31	34	51	57

Table 9.6 least cost ration formulation for female calves aged 3-6 months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	208	237	269	303	331	353	0	0	0	0	155	181
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	0	0	0	0	0	0	0	0	0	0	0	0
Bean straw	0	0	0	0	0	0	63	72	36	48	0	0
Maize silage	42	32	21	7	0	0	204	217	95	105	57	50
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	0	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	0	0	14	10	0	0	0	0
Corn	0	0	0	0	0	0	0	0	0	0	0	0
Wheat bran	0	0	0	0	0	0	94	99	43	39	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Nutrients availability (kg)												
DM (+10%)	250	270	290	310	331	353	375	397	174	193	212	231
TDN	152	162	173	183	194	207	248	262	114	125	131	141
CP	40	44	49	53	58	61	41	43	19	20	32	36

Table 9.7 least cost ration formulation for calves aged 0-3 months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Berseem	69	134	699	624	51	525	0	0	0	0	111	47
Darawa	0	0	0	0	0	0	0	0	0	0	0	0
Fodder beat	0	0	0	0	0	0	0	0	0	0	0	0
Corn stalk	0	0	0	0	0	0	0	0	0	0	0	0
Wheat straw	0	0	0	0	0	0	0	0	0	0	0	0
Rice straw	0	0	0	0	0	0	0	0	0	0	0	0
Bean straw	0	0	0	0	0	0	0	0	0	0	0	0
Maize silage	0	0	0	0	0	0	418	511	41	140	0	0
F. beat silage	0	0	0	0	0	0	0	0	0	0	0	0
Stover silage	0	0	0	0	0	0	0	0	0	0	0	0
Berseem silage	0	0	0	0	0	0	0	0	0	0	0	0
Clover hay	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ammoniated straw	0	0	0	0	0	0	0	0	0	0	0	0
Ureated m. stalk	0	0	0	0	0	0	0	0	0	0	0	0
Ureated r. straw	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 1	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 2	0	0	0	0	0	0	0	0	0	0	0	0
Concentrate 3	0	0	0	0	520	282	793	730	0	0	0	0
Corn	246	298	24	95	80	331	0	0	406	369	456	198
Wheat bran	0	0	0	0	0	0	0	44	0	0	0	0
Rice bran	0	0	0	0	0	0	0	0	0	0	0	0
Mofeed	0	0	0	0	0	0	0	0	0	0	0	0
Milk (fresh)	500	600	900	800	700	1000	1000	1000	900	900	900	400
Nutrients availability (kg)												
DM (+10%)	375	504	830	815	734	1258	1331	1405	555	616	675	293
TDN	237	317	429	442	454	768	842	893	354	393	430	186
CP	33	49	124	117	103	167	172	177	38	44	58	25

Table 10. Feeding cost per category of feeds and animals

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Feed categories												
Forage	1904	1978	2122	2084	1951	1249	0	0	0	0	1776	1808
Straws	11	18	14	15	15	69	99	225	262	48	8	10
Conserved forage	330	211	111	14	8	681	1411	1455	1345	1479	432	414
Treated straws	0	0	0	0	0	0	0	0	0	0	0	0
Concentrates	147	179	14	57	396	388	3096	2613	2483	3435	274	119
Animal Categories												
Milking cows	1491	1417	1305	1145	1068	1012	1819	1287	2509	3404	1528	1519
Heifer 1-2 years	185	188	191	198	205	212	617	519	355	352	179	182
Male 6-12 months	302	310	340	360	381	350	849	1089	543	548	264	282
Female 6-12 months	122	127	133	137	146	153	302	384	249	237	111	116
Male 3-6 months	82	87	93	98	103	108	255	235	122	106	71	76
Female 3-6 months	49	52	55	59	62	66	133	138	58	60	43	46
Calves 0-3 months	160	204	145	174	406	486	631	642	254	254	294	127
Overall	2392	2386	2262	2170	2370	2387	4605	4293	4090	4962	2490	2349

Table 11. Farm economics

	Production		Gross
	cost	value	margin
Crop			
Wheat	0	0	0
Broad bean	2955	3208	253
Maize	0	0	0
Rice	19553	81471	61918
Cotton	0	0	0
Subtotal	22508	84678	62171
Animal products			
Milk	19505	25112	5608
Body gain	17251	54973	37722
subtotal	36756	80086	43330
Total	59264	164764	105501

Chapter 5

Factors Influencing the Fermentation Characteristics of Maize Silages On-farm

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Factors Influencing the Fermentation Characteristics of Maize Silages On-Farm

Summary

One hundred and fifty five samples of maize silages made on-farm were taken during the filling of silos or after a certain time of ensiling. Silage quality was determined through visual inspection and on the basis of chemical composition, and related to: 1) Length of chopped materials that resulted from four different types of choppers; 2) variety, three maize varieties were included; 3) stage of maturity, age varying from 60 to 137 days at harvesting; 4) proportion of ears remaining with the stalks in terms of 0, 25, 33, 50, 66, 75 and 100% of the total grain yield; 5) length of ensiling period from 0 to 90 days.; 6) length of the period since opening of the silo, from 0 to 60 days . The impact of each individual factor was identified quantitatively and regression equations were formulated. Good quality silages were obtained, indicating adequate preservation for all silages. The highest qualities corresponded to whole-plant maize (without removing ears), ensiled at an average age of 108 days, after 17 days of fermentation, and, up to 45 days off-take feeding period (opening of the silo). Variety and type of chopper used in this study, had no significant effect on silage quality. The measured fermentation characteristic pH, lactic, acetic, propionic, butyric, iso-butyric, valeric, iso-valeric, total volatile fatty acid and NH_3/total N incorporated agreed well with the visual characteristics.

(**Key words:** maize silage, quality, fermentation characteristics)

Introduction

Animal feed resources in Egypt are a major limiting factor in exploiting the genetic potential of improved livestock. The type of feed resources that are conventionally available (primarily crop residues and other poor quality roughages) are of insufficient quality to meet their nutritional requirements. Most of these materials are low in protein and highly fibrous.

Many options have been presented to smallholder farmers to overcome the quantity and quality limitations of conventional feeds, such as the use of hybrid forage crops, chemical treatment of roughages and forage conservation. They have been introduced with varying degrees of success. Maize silage, which has in recent years been widely adopted on large-scale dairy farms in Egypt, has on a limited scale also been promoted with smallholder farmers. The potential benefits as indicated by on-station experiments, and the initially positive on-farm response to the technology, suggests that it could be adopted more widely.

It is unfortunate that much of the knowledge on feed utilization has not reached farmers for extensive adoption, so that the technologies that are transferred to the farmers are often not adopted in the most optimal way.

To ensure that on-station technical feasibility studies are relevant, more accurate on-farm information is needed on the quality of feed resources and the treatments applied. Even if the original material was of good quality, it may have been poorly conserved.

The aim of this study was to evaluate the quality of maize silage prepared by farmers, in comparison to on station prepared silage, and to quantitatively identify factors influencing the quality of the silage on-farm.

Materials and Methods

The quality of on-farm maize silage was assessed in comparison with characteristics of on-station maize silage, prepared under standard conditions. The on-farm silages were represented by one hundred and fifty five samples collected from different locations.

On-station silage making (control)

Whole white maize plants (hybrid, Giza 310) were harvested at different stages, chopped and conserved in a "three wall" concrete silo. The inner surface of the silo and the top of the chopped material were covered with plastic sheets. The silage was sampled for analysis after 90 days.

On-farm silage making/sample collection

Sampling. In an earlier survey[1], 994 farmers had been identified that had prepared silage. Hence, the sample (155) represents 16.4% of the total population. The respondents are spread over 13 villages in Ashmon district, situated in the Governorate of Monofia; in each village, silage of 12 different farmers was sampled. The respondents were randomly selected from the villages. Semi-structured interviews with questionnaire were used to collect relevant data for identifying and classifying the collected samples. Table 1 summarizes the factors influencing silage quality and the number of samples identified for each factor in the various villages.

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[1] The cooperative authorities in Ashmon and Monofia governorate identified a total of 994 smallholder farmers having prepared maize silage.

Sampling and chemical analysis

Representative samples were taken during the filling of silos and/or after a certain time of ensiling. The samples were stored in an ice box, transferred to the laboratory, dried in an oven at 60°C for about 48 hours, ground to pass a sieve of 1 mm, for proximate chemical analysis, following the conventional methods of A.O.A.C (1984). Silage dry matter (DM) content was determined following oven

Table 1. Factors influencing silage quality and description of variation

Factor	Description
Type of machine used[1]	Two types of imported choppers and two types of local choppers
Varieties	White maize (hybrid), Yellow maize (hybrid) and traditional variety
Stage of maturity	60 to 137 days after sowing
Fraction of grain used	0, 25, 33, 50, 66, 75 and 100% of the total grain yield*
Ensiling duration[2]	1 to 90 days
Off-take feeding period[3]	0 to 60 days open at time of sampling

[1] length of chopped material, [2] time between ensiling and opening, [3] time from opening to sampling

drying at 105°C for 24 hours. The fresh silage samples were analyzed in water extracts, prepared by extracting 100 g of homogenized wet material with 200 ml of 99% water +1% ortho-phosphoric acid (v/v). The homogenate was filtered through two-layers of cheese cloth and used for pH determination. For volatile fatty acids (VFA) analysis, 20 ml of the filtrated homogenate plus 20 ml diethyl ether were transferred to a separation funnel and after shaking, the upper layer was collected in a test tube. The procedure of adding diethyl ether was repeated three times until the ether remained colorless. All ether was banded/collected in one test tube. Half a ml of de-ionized water was added, and the test tube was shaken using a vortex mixer. The solution was then transferred to a freezer until the lower layer became frozen, allowing the upper layer to be removed easily. The aqueous fraction remaining in the test tube was used to analyze for VFA by HPLC under the following conditions:

Columns:	Rezex organic acid 30x4.6 mm (Phynomenix, USA)
Wavelength:	210 nm
Mobile phase:	1% ortho-phosphoric acid in water
Flow rate:	0.5 ml/min
Injection volume:	20 µl

Chemical and visual evaluation

Silage quality was estimated visually by examining the external characteristics of the material. Properties, such as color, odor and general appearance are useful indicators of expected overall silage quality. Visual evaluation will not provide accurate information on nutrient content of silage; that can only be estimated accurately through chemical analysis. However, in combination with chemical analysis of the ensiled materials and the fermentation characteristics, it can lead to accurate evaluation of the silage quality. Table 2 presents the set of visual and chemical characteristics used to evaluate the maize silages. These suggestions originate from the cited references or from direct observation by the authors.

Table 2. Preservation quality and characteristics of maize silages[1]

Characteristic	Good	Intermediate	Poor	Very poor
Visual				
Color	Light green	Yellowish green	Yellow to brown	Brown to black
Smell	Fermented fruits/slight old cheese smell	Acetic acid/slight butyric acid/slight ammonia	Butyric acid and strong ammonia smell	Strong butyric acid, odor rancid
Texture	Firm, with soft material not easily rubbed from fibre	Soft materials can be separated from fibre	Soft tissues easily rubbed from fibre	Compost
Chemical				
Moisture	65 to 70 %	Tends to be below 65%	Tends to be above 70 or below 50%	Tends to be above 70% or below 50%
pH	3.9 to 4.2	4.0 to 4.6	4.8 to 5.2	5.0 to 5.7
Lactic acid[2]	25 to 80	20 to 60	Below 25	Below 25
Total VFA[2]	Below 60	60 -100	100-140	Exceeding 140
Acetic acid[2]	Below 40	40 - 55	55 - 75	Exceeding 75
Propionic acid[2]	Less than 5	5 - 10	7 - 15	Exceeding 15
Butyric acid[2]	Below 5	5 - 15	15 to 20	Exceeding 20
Ammonia[3]	Below 10	10 - 15	15 - 20	Exceeding 20

[1] Modified from Tabana, 1994; van Os and Dulphy, 1996; Langstone et al., 1992; McDonald, 1981; McDonald et al., 1991. [2] Acetic, Propionic, Butyric and Total Volatile Fatty Acids are measured in g/kg dry matter. [3] NH_3-N : Total-N in g/kg

Classification of chopped materials

Representative samples (250 g each) of fresh or ensiled material were classified into four categories according to the length of chopped materials (Table 3)

Table 3. Classification of chopped materials

Class	Length (cm)	Main materials within classes
Fine	0 – 0.6	All fine stuff, including the grain
Small	0.6 – 3.5	Leaves, stems and cobs
Medium	1 – 4	Pith
Coarse	> 4	Mainly leaves and tops

Results and discussion

Many factors affect the chemical composition of forages and consequently their silages. Six major factors affect the fermentation characteristics and quality of silage, ranked according to their impact on silage quality: 1) variety, 2) proportion of grains left with the stover before ensiling, determining the content of soluble carbohydrates, 3) stage of maturity or stage of growth in terms of plant development, a common measure for describing forage quality, and plant age (length of period from sowing to cutting has been used for the same purpose) (Van Soest, 1994), 4) length of ensiling time, 5) off-take feeding period, 6) length of chopped materials.

Results indicated that no significant differences in CF, NFE and ash content were found in the silages of the different varieties (Table 4). CP and EE content were significantly higher in silages from yellow maize than in those from the other varieties.

Table 4. Chemical composition of ensiled varieties of maize.

Variety	No.* * of samples	% of ears	Av. age of maize (day)	Av. days of fermen-tation	Av. Days left at sampling	CP g/kg	EE g/kg	CF g/kg	NFE g/kg	Ash g/kg
Hybrid	130	84	103	36	12	74.6 ^{b}	18.3^{b}	286^{a}	525.8^{a}	94.7^{a}
Yellow	9	100	93	58	23	84.7 ^{a}	23.0^{a}	268^{a}	527.1^{a}	96.9^{a}
Baladi	16	87	98	43	16	72.3 ^{b}	18.8^{b}	271^{a}	543.8^{a}	93.5^{a}
Control	1	100	100	30	30	76.7 ^{b}	21.2^{b}	279^{a}	526.5^{a}	96.3^{a}

* a/b Means in the same column having dissimilar superscripts differ significantly (P<0.05).

** Each sample represents one farmer.

These differences may be related to intrinsic properties of the variety and/or they may be associated with other factors, such as the fraction of ears included in the silage and/or the age of the maize. This is illustrated in Table 5, where the percentage of ears or yield of grains removed before ensiling is given. These data show that CP and EE markedly decreased with the percentage of ears removed for ensiling. The opposite trend holds for CF content.

The linear regressions between percentage of ears in the silage and nutrient contents are shown in Figure 1 for CP, Figure 2 for EE, Figure 3 for CF and Figure 4 for NFE. The corresponding equations are:

$Y_{CP} = 48.226 + 0.3118\ X \quad (R^2 = 0.4022)$
$Y_{EE} = 12.855 + 0.0679\ X \quad (R^2 = 0.1409)$
$Y_{CF} = 321.25 - 0.4354\ X \quad (R^2 = 0.1928)$
$Y_{NFE} = 522.9 + 0.0543\ X \quad (R^2 = 0.0029)$

Where X= percentage of ears removed before ensiling

Fig. 1

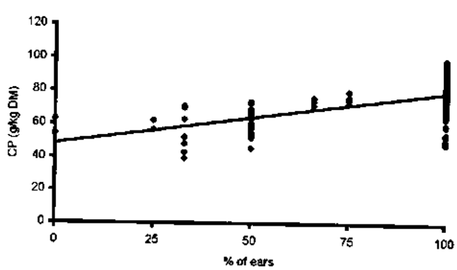


Fig. 3

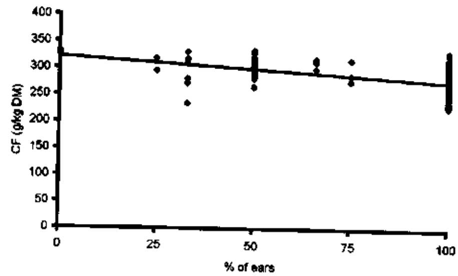


Fig. 2

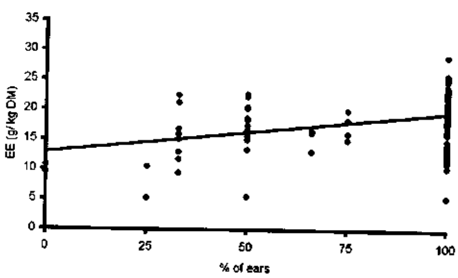


Fig. 4

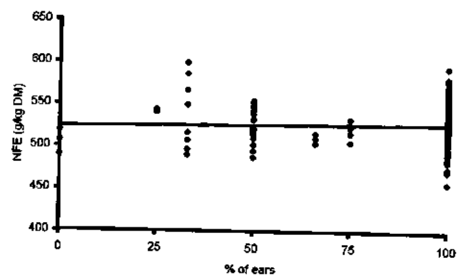


Table 5. Percentage of maize ears removed before ensiling and proximate chemical composition of silages.

% of ears removed	No of samples	Av. age of maize (day)	Av. days of fermentation	Av. Days left at sampling	CP g/kg	EE g/kg	CF g/kg	NFE g/kg	Ash g/kg
100	3	117	27	17	56.9	9.9	329.3	504.8	99.1
75	2	105	30	13	59.4	7.9	306.7	541.8	84.2
66	8	103	39	10	54.8	15.7	297.3	538.4	93.8
50	21	103	33	10	62	18	300.3	524	95.7
33	3	102	30	13	73.9	15.3	311.1	510.7	89
25	4	98	46	13	76	17.4	293	519.9	93.7
0	114	101	39	14	79.5	19.6	277.4	528.6	94.9

Moreover, the age of maize plants (or rather their phenological stage) at ensiling affects nutrient availability before and after fermentation (Table 6). The data indicate that CP and NFE decrease as age increases. This decline is related to the fact that at an early age mostly cell content is produced, and with increasing age more and more cell walls (Argillier et al., 1995; Bal et al., 1997). While CF and EE increase with age, the fibre content declines at early stages of maturity, because the proportion of grain in the silage increases. At later stages of maturity, the increase in fibre in the stalks offsets any increase in the proportion of grain (Bal et al., 1997). Similar trends for fibre content have been reported by Flachowsky et al., 1993; Wiersma et al., 1993 and Xu et al., 1995. These relationships are presented in Figures. 5, 6, 7 and 8 for CP, EE, CF and NFE, respectively. The associated regression equations are:

$Y_{CP} = 90.808 - 0.1559\,X$ $(R^2 = 0.0384)$

$Y_{EE} = 15.1507 + 0.0311\,X$ $(R^2 = 0.0112)$

$Y_{CF} = 196.67 + 0.8581\,X$ $(R^2 = 0.2855)$

$Y_{NFE} = 598.79 - 0.6999\,X$ $(R^2 = 0.1848)$

Where, X= age of maize (d) at ensiling.

Fig. 5

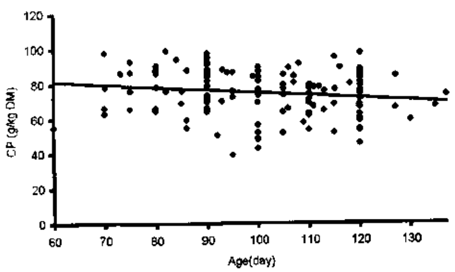


Fig.6

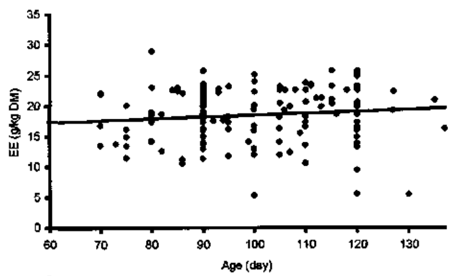


Fig. 7

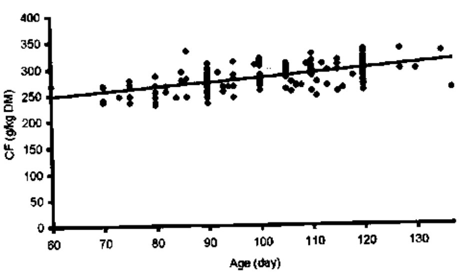
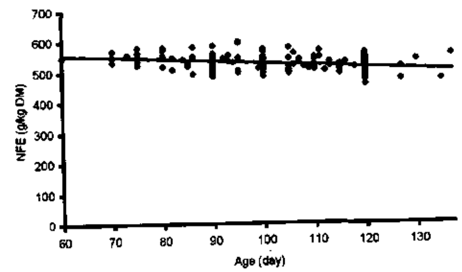


Fig.8



With regard to the effect of ensiling time length (in days), after 20 days of ensiling, the chemical composition of maize silages tends to stabilise. The data that shown in Appendix 1 indicated that length of ensiling has a relatively small effect.

Table 6. Proximate chemical composition of maize silage as a function of age at ensiling.

Av. age of maize (day)	No. of samples	% ears	Av. age of maize	Av. days of fermen-tation	Av. Days left at sampling	CP (g/kg)	EE (g/kg)	CF (g/kg)	NFE (g/kg)	Ash (g/kg)
60-70	5	---	68	27	10	72.1	18.4	255.3	554.3	99.9
71-80	14	95	78	33	13	81.1	17.5	255.0	551.2	95.2
81-90	35	90	89	40	17	79.8	18.7	273.9	531.0	96.6
91-100	26	82	98	37	14	72.1	17.5	287.9	533.3	89.2
101-110	24	78	108	34	11	72.5	18.1	288.9	524.4	96.1
111-120	46	86	119	40	12	73.0	20.1	296.8	515.5	94.6
121-130	3	83	128	34	4	70.1	15.8	309.1	509.6	95.4
130-140	2	100	136	46	7	70.5	18.8	294.5	514.3	101.9

Fermentation characteristics

The fermentation quality of silages can be characterized by their fermentation characteristics (van Os, 1997), organic acids, volatile fatty acids and ammonia (NH_3).

Variety

Very large differences in fermentation quality among silages from different varieties were expected. The protein (CP) and lipid contents (EE) (Table 4) in yellow maize were higher than those in hybrid and Baladi. However, these differences in fermentation quality were not found, This might be due to other factors such as 1) significant quantity of grain that may increase slightly with maturity, as grain content increases in the plant, 2) insect pests that can reduce forage quality, particularly if they cause significant leaf loss, 3) plant diseases can affect quality when they result in a shift in the varieties present in the field and when they accelerate leaf senescence. Insect pests and diseases generally have their strongest impact on yield and persistence of forages.

Fermentation characteristics of silages of the different varieties tend to be within the range associated with good quality silage (Appendix 2).

Percentage of ears remaining in the stover

One of the main factors that influences silage quality is the rate of pH decline in the early stages of fermentation (Heron et al., 1989; Merry et al., 1993; Williams et al., 1992). This pH decline is related to the rate of lactic acid production, which, in turn, is determined by the activity of the natural lactic acid bacterial population and the content and composition of water soluble carbohydrate (WSC) in the forage (Davies et al., 1998). The WSC concentration in the forages is strongly correlated with the percentage of ears remaining with the stover. Table 7 and Figures 9 and 10 show the relationship between fermentation characteristics and percentage of ears. It was expected that silage quality would increase with an increased proportion of grains: Lactic acid content markedly increased with increased ear contribution, pH and other fermentation characteristics, however, markedly decreased. Protein degradation, indicated by the ratio of ammonia nitrogen to total nitrogen content, increased with decreased ear contribution, as at higher pH, deamination is carried out largely by *Clostridia* bacteria (Ohshima and McDonald, 1978; Makoni et al., 1997). The level of lactic acid was negatively correlated to the other fermentation characteristics.

$Y_{pH} = 5.16 - 1.833\,X + 0.8722\,X^2$ ($R^2 = 0.2141$)

$Y_{Lactic\ acid} = 6.29 + 37.466\,X$ ($R^2 = 0.1723$)

$Y_{Total\ VFA} = 59.8 - 29.872\,X$ ($R^2 = 0.1257$)

$Y_{NH3\text{-}N\ :\ total-N} = 236.18 - 102.29\,X$ ($R^2 = 0.4929$)

$Y_{Acetic\ acid} = 80.971 - 132.3\,X + 80.126\,X^2$ ($R^2 = 0.1745$)

$Y_{Propionic\ acid} = 4.824 - 7.8908\,X + 4.7485\,X^2$ ($R^2 = 0.2094$)

$Y_{Butyric\ acid} = 1.5168 - 2.5659\,X + 1.3896\,X^2$ ($R^2 = 0.2372$)

$Y_{Isobutyric\ acid} = 0.4 - 0.7962\,X + 0.4241\,X^2$ ($R^2 = 0.2355$)

$Y_{Valeric\ acid} = 0.1999 - 0.3594\,X + 0.1988\,X^2$ ($R^2 = 0.1849$)

$Y_{Isovaleric\ acid} = 0.1225 - 0.2697\,X + 0.164\,X^2$ ($R^2 = 0.1274$)

Where, Y = concentration of certain fermentation product (g/kg) and X = percentage of ears remaining with the maize stover before ensiling.

Table 7. Effect of percentage of ears remaining with the stover on fermentation characteristics (g/kg dry matter, except for pH and L/A)

Characteristic	% ears remaining with stover						
	0	25	33	50	66	75	100
Number of samples	3	2	8	21	3	4	114
pH	5.05	4.89	4.75	4.41	4.48	4.13	4.12
Lactic acid	10.17	11.65	13.34	27.53	20.83	41.35	43.66
Acetic acid	72.55	65.43	53.03	32.32	33.81	17.13	28.98
Propionic acid	4.64	3.42	2.9	2	1.88	1.34	1.69
Butyric acid	1.4	1.13	0.92	0.54	0.57	0.22	0.34
Iso-butyric acid	0.38	0.33	0.27	0.13	0.13	0	0.07
Valeric acid	0.18	0.15	0.12	0.06	0.06	0.02	0.04
Isovaleric acid	0.11	0.09	0.06	0.03	0.02	0	0.02
Lactic : Acetic ratio (L/A)	0.14	0.18	0.27	1.47	0.66	2.46	2.53
Total Volatile Fatty Acids	79.3	70.5	57.3	35.1	36.5	18.7	31.1
Total Acids (TA)	89.4	82.2	70.6	62.6	57.3	60.1	74.8
NH_3-N	223	206	226	181	152	136	135

Fig. 9

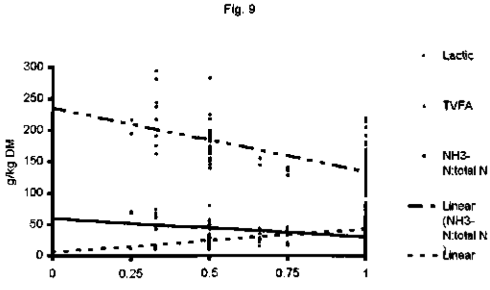
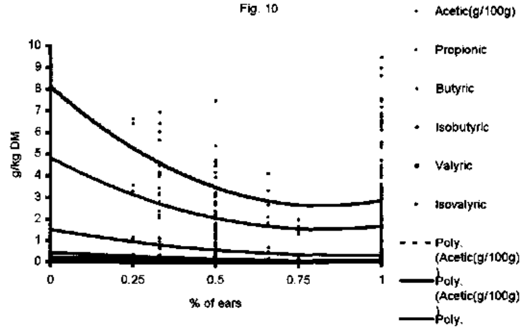


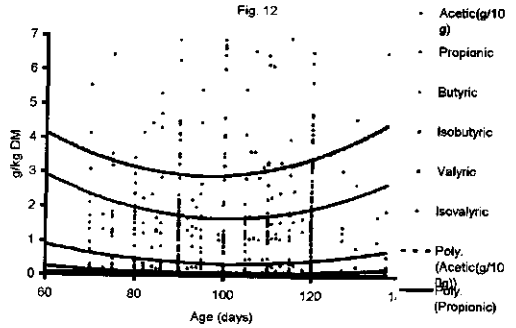
Fig. 10



Age (stage of maturity/phenoloy)

Silage pH was lower for silage from maize harvested at 90 to 110 days than for silages harvested earlier and later. This is associated with the higher concentrations of water-soluble carbohydrates and a more intensive fermentation (Fisher and Burns, 1987; McDonald et al., 1981). The same trends were found for the concentrations of TVFA and the NH_3-N/total-N ratio. The lactic acid concentrations and pH values varied little in silages from maize harvested over 90 days. However, higher pH coincided with lower lactate concentration (Bal et al., 1997).

Table 8 and Figures 11 and 12 show non-linear relationships between age at harvesting and fermentation characteristics. Lactic acid content reached its maximum at an average age of 98 to 108 days.



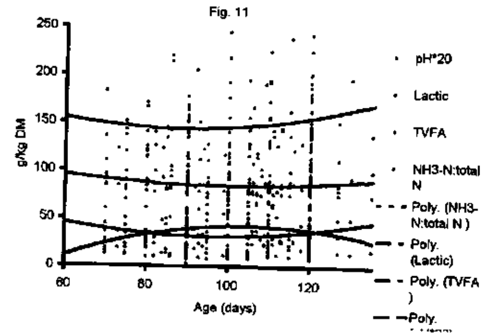


Table 8. Effect of maize age at harvest on fermentation characteristics (g/kg dry matter, except for pH and L/A) of the silage

	Age of maize (d)							
Range	60-70	71-80	81-90	91-100	101-110	111-120	121-130	130-140
Average	68	78	89	98	108	119	128	136
Number of samples	5	14	35	26	24	46	3	2
pH	4.55	4.31	4.35	4.14	4.15	4.32	4.19	4.52
Lactic acid	20.88	31.82	37.12	44.32	44.69	35.12	49.03	53.6
Acetic acid	38.44	25.41	32.87	30.82	28.72	33.43	30.41	53.62
Propionic acid	2.23	1.65	2.16	1.66	1.53	1.89	1.67	3.77
Butyric acid	0.64	0.38	0.53	0.35	0.3	0.44	0.34	0.96
Iso-butyric acid	0.17	0.06	0.12	0.07	0.06	0.09	0.09	0.29
Valeric acid	0.08	0.04	0.07	0.04	0.03	0.05	0.04	0.15
Iso-valeric acid	0.03	0.01	0.04	0.02	0.01	0.02	0.02	0.14
Lactic : Acetic ratio	0.82	1.88	2.32	2.95	2.47	1.61	2.15	2.93
Total Volatile Fatty Ac.	41.6	27.6	35.8	33	30.6	35.9	32.6	58.9
Total Acids (TA)	62.5	59.4	72.9	77.3	75.3	71	81.6	112.5
NH_3-N : total N	166	135	139	157	148	153	153	160

The regression equations that represent the above relationship are:

$Y_{pH} = 7.5414 - 0.0652 X + 0.0003 X^2$ ($R^2 = 0.0501$)

$Y_{Lactic\ acid} = -133.95 + 3.3815 X - 0.0162 X^2$ ($R^2 = 0.0436$)

$Y_{Total\ VFA} = 129.71 - 2.0288\ X + 0.0105\ X^2$ ($R^2 = 0.0105$)

$Y_{NH3\text{-}N\ :\ total-N} = 245.03 - 2.2551\ X + 0.0125\ X^2$ ($R^2 = 0.0205$)

$Y_{Acetic\ acid} = 114.83 - 1.7758\ X + 0.0092\ X^2$ ($R^2 = 0.0184$)

$Y_{Propionic\ acid} = 9.4168 - 0.1545\ X + 0.0008\ X^2$ ($R^2 = 0.0350$)

$Y_{Butyric\ acid} = 3.53 - 0.0626\ X + 0.0003\ X^2$ ($R^2 = 0.0393$)

$Y_{Isobutyric\ acid} = 1.1026 - 0.0205\ X + 0.0001\ X^2$ ($R^2 = 0.0408$)

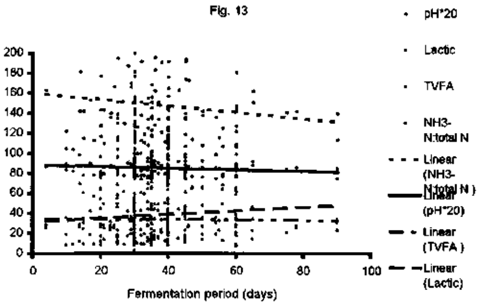
$Y_{Valeric\ acid} = 0.508 - 0.0093\ X + 0.00005\ X^2$ ($R^2 = 0.0372$)

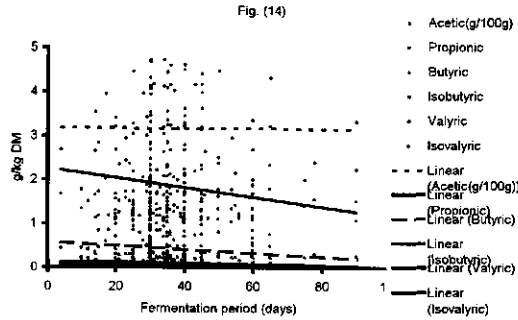
$Y_{Isovaleric\ acid} = 0.3251 - 0.0062\ X + 0.00003\ X^2$ ($R^2 = 0.0307$)

Where, Y = concentration of certain fermentation product in g/kg and X = age of maize (d)

Days of ensiling

The fermentation characteristics as a function of the length of the ensiling period are presented in Figures 13 and 14 and Appendix 3.





The results show that for all silages all fermentation characteristics remain stable after 17 days of fermentation. Subsequently, changes in the proportions of the major volatile fatty acids (acetic, propionic and butyric) were very limited. The pH values of all silages slightly increase, probably due to a secondary fermentation and because butyric acid was only detected in low concentrations in some silages. *Clostridia*, that ferment lactic acid, cannot be involved (Davies et al., 1998). However, increased production of acetic acid from lactic acid is a likely explanation, because of two possible reasons. Firstly, fermentation of lactic acid to acetic acid by lactic acid bacteria has been shown to occur under sugar-limiting conditions (Chen and McFeeters, 1986; Jones and Mangan, 1976; Rooke et al., 1990), which provides indirect support for the shift from lactic acid to acetic acid. Moreover, a similar rise in pH took place in the silages. Secondly, fermentative lactic acid bacteria, which are often present during the later stages of

ensiling, are more tolerant to acidic conditions (Mangan, 1982) and produce acetic acid in addition to lactic acid.
Comparing the fermentation characteristics (FP) at 8 days with their average over the period 17 - 100 days, $((FP_{8days} - FP_{average\ 17\text{-}100\ days})/ FP_{8days})$ shows a remarkable reduction in pH, acetic, propionic, butyric, isobutyric, valeric, isovaleric, total volatile fatty acids and in the NH3-N/total N ratio by 7, 24, 41, 49, 50, 48, 57, 24 and 16%, respectively. The effect of the length of the ensiling period on fermentation characteristics was calculated as:

Y_{pH}	$= 4.4162 - 0.0037\ X$	$(R^2 = 0.0160)$
$Y_{Lactic\ acid}$	$= 31.604 + 0.1856\ X$	$(R^2 = 0.0122)$
$Y_{Total\ VFA}$	$= 34.96 - 0.0199\ X$	$(R^2 = 0.0002)$
$Y_{NH3\text{-}N\ :\ total-N}$	$= 160.31 - 0.3209\ X$	$(R^2 = 0.0140)$
$Y_{Acetic\ acid}$	$= 31.867 - 0.0252\ X$	$(R^2 = 0.0193)$
$Y_{Propionic\ acid}$	$= 2.2657 - 0.011\ X$	$(R^2 = 0.0186)$
$Y_{Butyric\ acid}$	$= 0.5879 - 0.0043\ X$	$(R^2 = 0.0195)$
$Y_{Isobutyric\ acid}$	$= 0.1361 - 0.0012\ X$	$(R^2 = 0.0137)$
$Y_{Valeric\ acid}$	$= 0.0688 - 0.0005\ X$	$(R^2 = 0.0118)$
$Y_{Isovaleric\ acid}$	$= 0.0345 - 0.0003\ X$	$(R^2 = 0.0087)$

Where, Y = concentration of a certain fermentation products (g/kg) and X = days since the start of fermentation.

Length of feeding period after opening

After opening the silo for feeding, the front of the silage is continuously exposed to air and that cannot be prevented from entering. At this stage, large differences in response among silages have been recorded. Some remain apparently unaffected for more than one week, whereas extremely susceptible silages start deteriorating almost immediately after opening (Spoelstra, 1994). Fermentation characteristics as a function of time after opening the silo are given in Table 9 and Figures 15 and 16. The values of pH and TVFA slightly increase, while lactic acid and the NH_3-N/total N ratio decrease (Figure15). The individual VFAs, especially acetic acid markedly increase with time (Figure 16). This could be the result of the entrance of oxygen through the fermented mass, which causes a shift from lactic acid to acetic acid, through the action of lactic acid bacteria (Pahlow, 1982; Condon, 1987; Spoelstra, 1994) and of acetic acid bacteria oxidizing ethanol to acetic acid (Spoelstra et al., 1988). The relations between the length of the feeding period and fermentation characteristics were calculated as:

Y_{pH}	$= 4.3117 - 0.0037\ X + 0.0000006\ X^2$	$(R^2 = 0.0032)$
$Y_{Lactic\ acid}$	$= 36.795 + 0.2413\ X - 0.0043\ X^2$	$(R^2 = 0.0052)$

$Y_{\text{Total VFA}}$	$= 34.21 - 0.052\,X + 0.0019\,X^2$	$(R^2 = 0.0026)$
$Y_{\text{NH3-N : total - N}}$	$= 147.17 + 0.431\,X - 0.0112\,X^2$	$(R^2 = 0.0197)$
$Y_{\text{Acetic acid}}$	$= 31.649 - 0.0419\,X + 0.0018\,X^2$	$(R^2 = 0.0031)$
$Y_{\text{Propionic acid}}$	$= 1.9194 - 0.0047\,X + 0.000002\,X^2$	$(R^2 = 0.0021)$
$Y_{\text{Butyric acid}}$	$= 0.4603 - 0.0036\,X + 0.000005\,X^2$	$(R^2 = 0.0026)$
$Y_{\text{Isobutyric acid}}$	$= 0.1041 - 0.0014\,X + 0.000\,002\,X^2$	$(R^2 = 0.0039)$
$Y_{\text{Valeric acid}}$	$= 0.0529 - 0.0003\,X + 0.0000004\,X^2$	$(R^2 = 0.0009)$
$Y_{\text{Isovaleric acid}}$	$= 0.0246 - 0.0002\,X + 0.0000002\,X^2$	$(R^2 = 0.0010)$

Where, Y = concentration of certain fermentation products (g/kg) and X = number of days the silo has been open for feeding.

Fig. 16

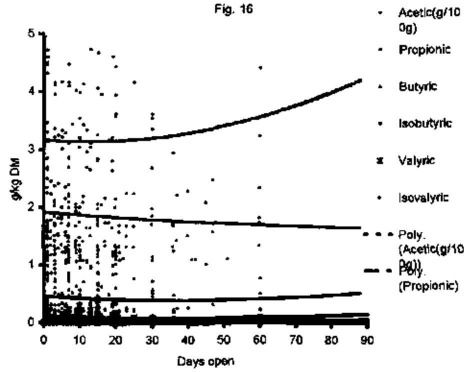
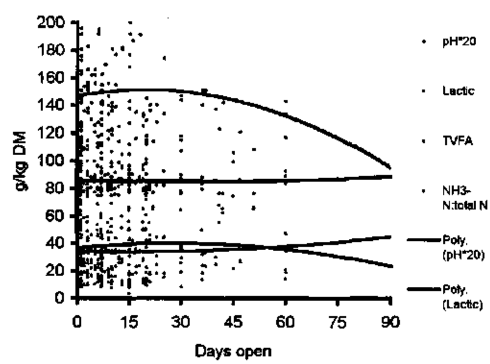


Fig. 15



Length of chopped materials

The length of the chopped materials is one of the main criteria determining the quality of a chopper. Obviously, all choppers produce different lengths at the same time, however, the proportions of these different lengths play a significant role in evaluating the choppers. These proportions also play an indirect role through their influence on the effectiveness of compaction of the materials and sealing of the silos. Choppers, when compared with other types of forage harvesters appear only useful for wet materials with relatively low DM content (Pickert et al., 1998). The chopped materials have been classified into categories as shown in Table 3.

The percentage of each category was identified and relative weights were given to these categories. Table 10 shows the percentage of each length of the chopped materials and the weights given. The overall weight (calculated by multiplying the

Table 9. Fermentation characteristics (g/kg dry matter, except for pH and L/A) as a function of the length of the period (d) after opening the silos for feeding.

	Off take feeding period												
Range	1	2	3	4	5	6-10	11-15	16-20	21-25	26-30	31-45	46-60	61-90
Average	1	2	3	4	5	8	14	19	23	30	39	56	91
Number of samples	5	27	4	11	5	38	21	17	8	5	8	5	1
pH	4.3	4.17	4.18	4.26	4.51	4.27	4.43	4.3	4.14	4.21	4.06	4.29	4.65
Lactic acid	38.52	38.8	44.26	31.93	22.32	39.22	33.83	37.73	42.71	41.34	50.99	32.76	14.1
Acetic acid	35.84	18.32	25.3	23.93	37.49	29.46	38.54	31.56	25.89	27.89	30.12	36.86	44.54
Propionic acid	1.93	1.39	1.52	1.55	2.18	1.89	2.41	1.91	1.42	1.56	1.31	1.64	2.35
Butyric acid	0.45	0.23	0.33	0.34	0.6	0.44	0.62	0.45	0.26	0.33	0.19	0.38	0.82
Iso-butyric acid	0.1	0.02	0.06	0.05	0.14	0.09	0.16	0.1	0.03	0.07	0.02	0.08	0.25
Valeric acid	0.05	0.02	0.03	0.04	0.07	0.05	0.08	0.05	0.02	0.04	0.02	0.04	0.1
Isovaleric acid	0.02	0	0.01	0.01	0.03	0.03	0.05	0.02	0	0.01	0	0.01	0.05
Lactic : Acetic ratio (L/A)	2.14	2.86	2.74	1.62	0.79	2.38	1.82	2.28	2.3	2.61	2.12	1.03	0.32
Total Volatile Fatty Acid (TVFA)	38.4	20	27.2	25.9	40.5	32	41.9	34.1	27.6	29.9	31.7	39	48.1
Total Acids (TA)	76.9	58.8	71.5	57.8	62.8	71.2	75.7	71.8	70.3	71.2	82.6	71.8	62.2
NH_3-N	147	134	143	145	146	147	170	159	140	126	144	125	123

category weight by its percentage) was used to judge the choppers performance regarding lengths of chopped materials. No significant differences were observed among the choppers. All choppers performed non- homogeneous lengths of chopped materials or mix of lengths. The effects of chopper type on fermentation characteristics of the silages, presented in Appendix 4, show no significant differences (P>0.05) among silages. The low pH, TVFA, NH_3-N, butyric acid and the high lactic acid concentration are all indications that all silages were well preserved.

Table 10. Weights and percentages of chopped materials per category and per type of chopper

Category of chopped materials	Percentage of weight	Type of Machine (chopper)			
		Baladi	Emagro	PZ	Claas
		Weight of categories			
Number of samples		89	22	19	25
Fine	45	35.41	33.48	37.44	44.97
Small	30	29.89	31.4	29.7	23.68
Medium	15	7.37	5.42	2.07	4.06
Coarse	10	27.33	29.7	30.79	27.29
Overall weight		2874[a]	2821[a]	2915[a]	3068[a]
Rank		3	4	2	1

Conclusion

Small farmers adopted silage-making intervention as indicated by the quality of maize silage produced on-farm.

The highest qualities corresponded to whole-plant maize (without removing ears), ensiled at an average age of 108 days, after 17 days of fermentation, and, up to 45 days off-take feeding period (opening of the silo). Variety and type of chopper used in this study, had no significant effect on silage quality.

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Appendix 1. Proximate chemical composition of silages in relation to the length of ensiling time.

Days from ensiling to opening	No. of samp-les	% ears rema-ining	Av. age of maize	Av. days of fermen-tation	Av. Days left at sampling	CP g/kg	EE g/kg	CF g/kg	NFE G/kg	Ash g/kg
<10	3	67	104	8	6	69.1	12.4	278.1	546.2	94.2
11-20	13	89	102	17	8	72.5	18.6	289	522.1	97.8
21-30	47	85	99	28	11	74.7	18.4	284.3	528.9	93.7
31-40	56	86	101	37	14	75.5	18.7	284.8	525	96.0
41-50	16	71	104	46	18	71.9	16.9	287.8	531.2	92.2
51-60	13	100	106	58	15	79.2	21.2	273.3	532.2	94.1
>60	7	96	109	100	16	78.7	22	280.1	525.4	93.8

Appendix 2. Fermentation characteristics (g/kg dry matter, except for pH and L/A) of silages from different varieties.

	Hybrid	Yellow	Baladi
pH	4.27	4.33	4.36
Lactic acid	39.54	30.83	32.83
Acetic acid	32.15	27.24	31.3
Propionic acid	1.86	1.74	1.96
Butyric acid	0.43	0.42	0.48
Iso-butyric acid	0.09	0.09	0.11
Valeric acid	0.05	0.05	0.06
Isovaleric acid	0.02	0.02	0.03
Lactic : Acetic ratio (L/A)	2.22	1.73	1.83
Total Volatile Fatty Acids (TVFA)	34.6	29.5	33.9
Total Acids (TA)	74.1	60.4	66.8
NH_3-N	149	131	154

Appendix 3. Effect of length (day) of the ensiling period on fermentation characteristics (g/kg dry matter, except for pH and L/A).

	Length (d) of ensiling period						
Range	<10	11-20	21-30	31-40	41-50	51-60	>60
Average	8	17	28	37	46	58	100
Number of samples	3	13	47	56	16	13	7
PH	4.6	4.32	4.33	4.23	4.33	4.17	4.3
Lactic acid	23.38	37.59	34.11	43.39	33.57	44.92	33.01
Acetic acid	41.97	31.33	30.39	30.86	38.45	31.74	29.69
Propionic acid	3.08	2.02	1.98	1.73	1.87	1.72	1.65
Butyric acid	0.83	0.48	0.48	0.38	0.47	0.33	0.38
Iso-butyric acid	0.18	0.11	0.1	0.08	0.11	0.06	0.08
Valeric acid	0.1	0.06	0.06	0.04	0.06	0.04	0.05
Isovaleric acid	0.05	0.03	0.03	0.02	0.02	0.02	0.01
Lactic : Acetic ratio (L/A)	1.03	2.8	2.17	2.33	1.2	2.65	1.19
Total Volatile Fatty Acid (TVFA)	46.2	34	33	33.1	41	33.9	31.8
Total Acids (TA)	69.6	71.6	67.1	76.5	74.5	78.8	64.9
NH_3-N : total N	176	157	150	145	160	135	136

Appendix 4. Effect of type of chopper, maize characteristics and silage characteristics on fermentation characteristics (all in g/kg dry matter, except for pH and L/A).

Item	Type of chopper			
	Claas	PZ	Emagro	Baladi
% of ears	0.91	0.83	0.84	0.85
Average age of maize (d)	101	98	102	103
Average length of ensiling period (d)	38	36	41	37
Average length of period after opening (d)	22	12	9	12
pH	4.26	4.27	4.29	4.29
Lactic acid	41.21	37.08	38.29	37.83
Acetic acid	33.06	27.57	34.2	31.71
Propionic acid	1.79	1.68	2.04	1.88
Butyric acid	0.39	0.39	0.47	0.44
Iso-butyric acid	0.08	0.08	0.11	0.1
Valeric acid	0.05	0.04	0.05	0.05
Isovaleric acid	0.02	0.01	0.03	0.02
Lactic : Acetic ratio (L/A)	1.85	2.21	2.17	2.22
Total Volatile Fatty Acid (TVFA)	35.4	29.8	36.9	34.2
Total Acids (TA)	76.6	66.8	75.2	72
NH_3-N : total N	144	147	145	151

Chapter 6

Introducing Maize Silage into the Egyptian Feeding Systems: Ensiling Characteristics, Digestibility and Feeding Value, and Interactions with Berseem-based Feeding Systems

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Introducing Maize Silage into the Egyptian Feeding Systems: Ensiling Characteristics, Digestibility and Feeding Value, and Interactions with Berseem-based Feeding Systems

Summary

Four feedstuffs: berseem (Trifolium alexandrinum) rice straw, concentrate mixture and maize silage were used in two direct and three indirect metabolism trials with sheep. In trials 1 and 5, berseem (B) and maize silage (M) were fed alone. In trials 2, 3 and 4, a restricted quantity of wilted berseem (approximately 250 g DM) was fed, to cover 30 to 40% of total DM intake, the remainder being covered partly by concentrates (C), rice straw (R), or maize silage (M) in trials 3, 4 and 5, respectively.

The silage was well preserved, as indicated by its low (35.35 g/kg DM) content of total volatile fatty acids (VFA). Except for acetic and propionic acid, the silage was free from undesirable VFA's (less than 1 g/kg DM). Ammonia-N concentration was generally low (1.7 g/kg DM), reflecting a relatively rapid rate of lactic acid production and limited proteolysis. However, a high lactic acid content (63.6 g/kg DM) and a low pH (3.84) were found. The efficiency of fermentation was favorable, as indicated by the ratio of lactate to acetate (2.17).

To study the development of the fermentation, small-scale ensiling experiments were carried out: they showed a rapid drop in pH during the first 8 days (from 6.6 to 4.85), up to 16 days (during the second week) the changes were moderate (from 4.85 to 4.6), and subsequently, up to 96 days, the values remained within narrow limits (3.87 ± 0.06).

BR showed the lowest digestibilities for all components; M the highest DM (69.9 vs. 59.3) and OM (74.6 vs. 57.3) digestibilities. Feeding M with B increased DM digestibility by 1.7 unit and decreased the OM digestibilities by 3.2 units compared to feeding M alone.

There was no significant difference ($P<0.05$) between B and M in digestibility of any fiber fraction, except for NDF. Berseem, being a legume, tends to have lower digestibility than maize silage, belonging to the graminae. On the other hand, significant differences ($P>0.05$) were found for C, R and Mi (maize silage calculated by difference) for all fractions, except for NDF between C and Mi.

For hemicellulose and cellulose, digestibilities were almost identical for B and M, while for Mi it was 6 units lower than for M. Comparison of the fiber fractions for C, R and Mi (calculated by difference) showed that for hemicellulose, digestibility of Mi was highest, that for R lowest, the inverse trend was found for cellulose digestion. The same trend was found for BC, BR and BM, which can be ranked according to the digestibility coefficient as BM>BC>BR and BR>BC>BM for hemicellulose and cellulose, respectively.

DM intake of M was higher than of B, indicating that B intake may be more related to the rumen fill and digestibility. Intake of BM was higher than of BR and lower than of BC. TDN and DCP values are in agreement with the data in the region, in descending order, C>M>B>R for TDN and B>C>M>R for DCP.

(key words: berseem, maize silage, rice straw, digestibility, fermentation, nutritive value)

Introduction

In dairy production, both the quantity and quality of the feed play an important role. In Egypt, this is an especially pressing problem, as animal demand for nutrients is high and the energy content of the most commonly available forage, clover (*Trifolium alexandrinum)* is low.

Diets composed of low quality roughages only are usually not adequate to sustain high milk production, and need to be supplemented to increase the available energy (Tamminga and Jansman, 1997). Using the services of a feed mill, that has facilities to formulate least cost rations, is a theoretical option. However, the quality of a mixed concentrate, composed of a wide variety of ingredients is not always guaranteed. Low quality roughages in the form of crop by-products are widely available, but the low digestibility of these materials limits their use as a source of energy, particularly for milking cows. Homegrown conserved forages may offer an alternative for overcoming the problem.

Maize silage, in recent years widely adopted on large-scale dairy farms in Egypt, has also been promoted with smallholder farmers in a limited number of areas. The potential benefits as indicated by on-station experiments, in combination with the initial positive on-farm response to the technology, suggests that it might be adopted more widely.

Although the on-farm fermentation characteristics of maize silage is fairly well established (Tabana et al., 2000), little information is available on its interaction with other dietary ingredients.

The aim of this study was a detailed analysis of the conservation process of maize silage under conditions prevailing in Egypt, and to establish its interaction with other components of a diet common (in winter) for dairy cows at low and medium milk production.

Materials and Methods

Feedstuffs

Four feedstuffs were investigated in this study: rice straw, maize silage, berseem clover

(*Trifolium alexandrinum*) and concentrate mixture.

Rice straw: Straw from a hybrid variety was used. To limit losses during feeding, the straws were chopped into pieces of 15 centimeter.

Maize silage: Whole white maize plants (hybrid, Giza 310) were harvested at the hard dent stage of maturity (100 days), chopped and conserved in a "three wall" concrete silo. The inner surface of the silo and the top of the chopped material were covered with plastic sheets. After 90 days of ensiling, the silo was opened for analysis.
To study the development of silage quality, ten polyethylene bags were filled with chopped maize, sealed and placed in a closed/dark cupboard for analysis after different lengths of the ensiling period.

Berseem: A third cut of berseem (Meskawy, improved variety) was harvested by hand after 35 days re-growth and a length of approximately 60 cm. Pre-wilting was performed in a shaded place for 24 hours before feeding.

Concentrate mixture: The composition of the commercial concentrate mixture, as specified by the manufacturer, was: Yellow maize (65%), cotton seed cake (10%), wheat bran (15%), rice bran (5%), molasses (2.5%), limestone (1.5%), salt (1%), and a mixture of trace elements and vitamin premix.

Metabolism trials

Two direct and three indirect metabolism trials were carried out, each with four castrated two-year-old Ossimy rams. To avoid sources of variability among different individuals, the same animals were used in the direct and indirect trials. An adaptation period of 21 days preceded each trial. The fecal collection period was 7 days. Metabolic cages were used, as described by Loosli (1969), slightly modified for better ventilation and easier collection.

Sampling and chemical analyses

Composition of the fresh silage samples was analysed in water extracts, prepared by extracting 100 g homogenised wet material with 200 ml liquid, consisting of of 99% water +1% ortho-phosphoric acid (v/v). The homogenate was filtered through two-layered cheese cloth, then used for silage quality determination. Volatile fatty acids (VFA) were determined using KENAUER High Performance Liquid Chromatography (HPLC). The device and separation conditions were columns: Rezex organic acid 30x4.6 mm (phynomenix, USA), detection wavelength: 210 nm., mobile phase: 1%

ortho-phosphoric acid in water, flow rate: 0.5 ml/min., injection volume: 20 µl. Feedstuffs were sampled regularly and representative samples of faeces were taken daily from the animals during the experimental period, as described by van Soest (1994). The samples were stored frozen, dried in an oven at 60 °C for about 48 hours, thoroughly ground in a wily-mill to pass a sieve of 1 mm, for proximate chemical analysis, following the conventional methods of A.O.A.C (1985). Silage and faeces dry matter (DM) contents were determined after oven drying at 105 °C for 24 hours. Neutral-detergent fiber (NDF), acid-detergent fiber (ADF) and acid-detergent lignin (ADL) were measured according to Goering and Van Soest (1970). Hemicellulose was calculated as NDF-ADF, and cellulose as ADF-ADL.

Experimental procedures

To avoid feed losses and/or refusal, feed intake were measured during the preparatory period and a proximate quantities of the measured intake were divided into two portions and offered to the animals at 8 a.m. and 5 p. m. The quantities of feed were adjusted daily to guarantee *ad libitum* feeding with minimum refusals (100 g/day). Berseem and rice straw were cut/chopped into pieces, of length 20 centimeters (approximately), and mixed before feeding. Also, concentrates and maize silage were mixed before feeding. In trials 1 and 5, berseem (B) and maize silage (M), respectively were fed as single feed. In trials 2, 3 and 4, a restricted quantity of berseem (approximately 250 g/head/d) was fed, covering 30 to 40% of the total DM intake. The remainder was covered by concentrates (C), straw (R) and maize silage (M) in trial 2, 3 and 4, respectively.

Results and Discussion

Silage characteristics

Fermentation characteristics of the silage are given in Table 1. The silage was well preserved as indicated by the low (35.35 g/kg DM) content of total volatile fatty acids. Except for acetic and propionic acid, the silage was free from undesirable VFAs (less than 1 g/kg DM). Also, silage pH and lactic acid concentration was indicative of adequate preservation (McDonald et al., 1991). The low pH and high lactic acid content are due to the high concentrations of water-soluble carbohydrates and more extensive fermentation (Flachowsky et al., 1993). Ammonia-N concentrations were generally low (1.7 g/kg DM), representing 11% of the total nitrogen (110 g/kg). This reflects a relatively high rate of lactic acid production and limited proteolysis (Heron et al., 1989; Williams et al., 1992), while the high lactic acid content and low pH inhibit activity of aerobic organisms such as *Clostridia*. The efficiency of fermentation was favourable, as indicated by the ratio of lactate to acetate (Luther, 1986; Cleale et al., 1990).

Table 1. Fermentation characteristics (all values in g/kg dry matter, except for pH, L/A and NH_3-N: total N)N of maize silage

Characteristic	Value
pH	3.84
Lactic acid	63.66
Acetic acid	29.22
Propionic acid	5.69
Butyric acid	0.31
Iso-butyric acid	0.09
Valeric acid	0.04
Isovaleric acid	0.002
Lactic : Acetic ratio (L/A)	2.17
Total Volatile Fatty Acids (TVFA)	35.35
Total Acids (TA)	99.0
NH_3-N	1.7
NH_3-N: total N	0.11

Fermentation development

The results of the simulated ensiling experiment (Table 2), show a fast drop in pH values during the first 8 days (from 6.6 to 4.6), while up to 16 days (during the second

Table 2. Development of fermentation characteristics (all in g/kg dry matter) in 'simulated' maize silage.

Time(days)	pH	Lactic	TVFA	Acetic	Propionic	Butyric	NH_3-N
0	6.6	ND*	ND*	ND*	ND*	ND*	137.8
1	5.3	36.3	5.6	5.2	0.2	0.096	130.3
2	5.01	45.2	11.5	10.7	0.5	0.19	126.1
4	4.85	47.9	15.0	13.3	1.1	0.5	119.6
8	4.6	49.4	18.8	14.1	2.3	2.3	97.2
16	3.74	52.4	29.1	14.5	4.8	9.7	101.1
32	3.89	61.3	30.7	15.3	5.1	10.2	99.6
48	3.83	64.1	37.8	18.9	6.3	12.6	102.7
64	3.95	61.6	36.4	18.2	6.0	12.1	98.5
80	3.79	62.6	36.9	18.4	6.1	12.3	101.7
96	3.91	60.7	35.8	17.9	5.9	11.9	101.6

* Not determined

week) the changes were moderate (3.74), and up to 96 days pH remained within narrow limits (3.87±0.06). Lactic acid concentration showed the inverse trend: it increased markedly during the first 8 days. The rate of decline in pH in the early stages of fermentation (Heron et al., 1989; Merry et al., 1993; Williams et al., 1992) is a reflection of the rate of lactic acid production, which, in turn, is determined by the activity of the natural lactic acid bacterial population and the content and composition of water soluble carbohydrate (WSC) in the forage (Davies et al., 1998). The number of lactic acid bacteria remains high after 10 days of fermentation (van Os et al., 1996) which explains the limited changes in pH and lactic acid during the period from 16 to 96 days.

Chemical composition

The chemical composition of the feedstuffs, presented in Table 3, shows substantial variation among individual feedstuffs. The variation reflects the differences in quality.

Table 3. Proximate chemical composition and fiber fraction for feedstuffs and rations

	Exp.1	Exp.2 [ii]	Exp.3 [ii]	Exp.4 [ii]	Exp.5	Exp.6 [i]	Exp.7 [i]
Feed mixtures [iii]	B	BC	BR	BM	M	C	R
Ingredient ratios	100	28 : 72	39 : 61	34 : 66	100	100	100
Proximate analysis (g/kg DM)							
DM	171	---	---	---	352	915	926
CP	174	170	100	120	93	168	52
EE	14	28	10	20	23	34	7
CF	207	149	307	263	292	127	372
NFE	461	530	433	489	503	556	413
Ash	144	122	151	108	89	114	155
Fiber fractions (g/kg)							
NDF	414	368	585	433	442	351	696
ADF	352	210	417	286	251	155	458
Hemicellulose	62	159	168	147	191	196	237
ADL	79	46	79	53	39	34	79
Cellulose	274	164	337	233	212	122	379

i Calculated by the difference method from experiments 1, 2 and 3.

ii Estimates based on results of exp. 1, 5, 6 and 7, by applying such combination at the same ratio of DM intake.

iii B= Berseem, BC= Berseem + Concentrate, BR= Berseem + Rice straw, BM= Berseem + Maize silage, M= Maize silage, C = Concentrate and R= Rice straw.

Low (52 g/kg DM) and moderate (93 g/kg) CP (crude protein) content was found in rice straw and maize silage, respectively. The concentrate mixture was highest in NFE (Nitrogen Free Extract) and EE (Ether Extract), followed by maize silage, berseem and rice straw. In experiments 2, 3 and 4, berseem was combined with concentrate, rice straw and maize silage in proportions of 28, 39 and 34% on a dry matter basis, respectively. This resulted in relatively high, moderate and low CP, EE and NFE contents for the mixtures containing concentrates, maize silage and rice straw, respectively. Rice straw had the highest crude fiber content, compared with berseem and maize silage. These results were confirmed by fiber fraction analysis (Table 3), which indicated that rice straw contained the highest proportions of all fiber fractions, except hemicellulose. When berseem was mixed with 61% straw (DM basis) NDF, ADF, hemicellulose and cellulose contents increased. The mixture of berseem with rice straw contained the highest hemicellulose content.

Feed intake

DM intake of M was appreciably higher than of B (Table 4), which indicates that B intake may be more related to rumen fill and/or digestibility (Bosch et al., 1991; Van Soest, 1994). Intake of BM was higher than of BR and lower than of BC. Higher silage intake has been reported when animals were fed fiber-based, rather than starchy supplements (Thomas et al., 1986; Phipps et al., 1987), though sometimes the differences were small (Castle et al., 1981; Mayne and Gordon, 1984; Huthanen, 1987).

Table 4. Intake and feeding values of the experimental feeds

	B	BC	BR	BM	M	C	R	Mi
Intake (g/d)								
DM	448	910	623	747	634	659	378	494
CP	78	154	62	90	59	110	20	46
NDF	263	335	365	323	354	231	263	218
Hemicellulose	158	145	105	110	159	129	90	94
ADL	28	42	49	39	121	22	30	19
Cellulose	35	142	204	167	25	80	143	105
Substitution rate	---	0.30	0.54	0.40	---	---	---	---

Because intake was almost ad lib, from the figures in table 4 substitution rates (SR= kg DM of berseem substituted per kg DM of supplement) can be calculated. They were 0,54, 0.40 and 0.30 for rice straw, maize silage and concentrates respectively. The figures for rice straw and Maize silage are surprisingly low. Because of their bulkiness one would expect figures close to or even higher than 1.0. The reason why they are far below 1.0 must be because berseem has a surplus of rumen degradable N of which rice straw and maize silage have a shortage.

Therefore, DM intake of maize silage was higher than of berseem (634 vs. 448 g/d) and higher when mixed with berseem (747 vs. 634 g/d). A positive effect on intake was also observed when berseem was mixed with rice straw. Protein supplements (Egan, 1977) have been suggested to increase intake through improved protein supply, and through changes in the protein/energy ratio that lead to improved nutritional status of the animals. Accordingly, high protein intake in the BC, BM, and BS rations (154, 90 and 62 g/d) appears to have led to relatively high DM intake (910, 747 and 623 g/d).

Correlation between intake and chemical composition

With respect to chemical composition, feeding values, and feed intake, data in Table 5 indicate that DM intake is positively correlated with TDN and negatively with the fiber fractions. Dietary NDF concentration is negatively correlated with hemicellulose intake.

Table 5. Correlation coefficients between intake values and chemical composition

	DM_I	NDF_i	ADF_i	Hem_i	ADL_i	$Cell_I$	$TDN_{\%}$	NDF_c	ADF_c	Hem_c	ADL_c	$Cell_c$
DM_I	1											
NDF_i	0.66	1										
ADF_i	0.31	0.83	1									
Hem_i	0.76	0.63	0.10	1								
ADL_i	0.41	0.73	0.91	0.03	1							
$Cell_I$	0.26	0.86	0.98	0.17	0.82	1						
$TDN_{\%}$	0.54	-0.13	-0.43	0.37	-0.34	-0.46	1					
NDF_c	-0.56	0.22	0.44	-0.22	0.22	0.53	-0.87	1				
ADF_c	-0.59	0.14	0.56	-0.53	0.43	0.57	-0.89	0.90	1			
Hem_c	-0.09	0.20	-0.15	0.57	-0.39	0.01	-0.18	0.45	0.01	1		
ADL_c	-0.48	0.09	0.56	-0.63	0.59	0.51	-0.81	0.70	0.92	-0.29	1	
$Cell_c$	-0.57	0.21	0.56	-0.41	0.37	0.61	-0.89	0.96	0.98	0.17	0.84	1

* The subscript letter c mean chemical composition and I mean intake

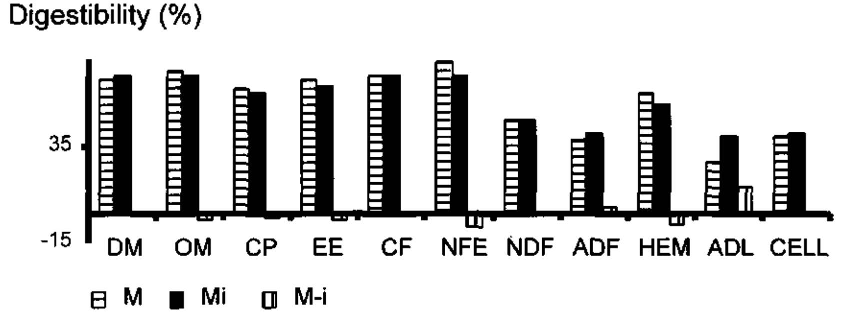
Digestibility

The digestibility of both the total and the fractional fiber components of the feedstuffs and the mixtures are presented in Table 6. The effects on digestibilities of combining berseem with maize silage were calculated as:

Effect on nutrient X $_{(CP, EE, etc)}$ $= Mi_x - M_x$

Where, Mi_x is the digestion coefficient for maize silage calculated from the difference between trials 1(B) and 4 (BM), and M_x is the digestion coefficient calculated from the direct trial 5 (M). The digestion coefficients of BM, M and *Mi* as well as the combination effects on nutrient digestibilities are presented in Figure 1.

Figure 1. The digestion coefficients of maize silages estimated directly (M), by difference (*Mi*) and the differences between the two measurements.



The digestibilities of all fractions distinguished in the proximate analysis (Table 6) of the two forages fed individually (B and M), were significantly different (P>0.05), except for the EE fraction. The values for BC, BR and BM were also significantly different (P>0.05) for all proximate fractions, except for CF between BC and BR. BR showed the lowest values for all components, i.e. for DM and OM 59.3% and 57.3%, respectively. M showed the highest digestibilities for DM (69.9%) and OM (74.6 %).

Mixing B with M decreased both DM and OM digestibility by 1.0 (N.S), and 3.2 units, respectively, compared to feeding M alone. B had the highest (73.8 %) CP digestibility, followed by BM (68.2 %) and M (64.5 %), R (15.9 %) the lowest. This is associated with the properties of the protein (Van Soest, 1994). In fresh forage (B) half of the true protein is in water-soluble form, while maize silage also has a relatively high NPN (non-protein nitrogen)-content compared to concentrate or straw.

EE digestibility did not differ significantly (P>0.05) among B, BM, M and Mi or between BC and C. This may be due to the quality and quantity of the EE intake along with the interaction with the other nutrients. However, the values for BR and R were significantly different from that for B. The EE digestibilities decreased in the order C (80), M (69.5), B (66.9) and R (17.2). The combination of B with C, R or M leads to EE digestibilities as predicted from the weighted averages for the single feeds.

The digestion coefficients of crude fiber (CF) were significantly different (P>0.05) for all diets, except for BC and BR and for C and R. These relative differences in digestibility probably reflect differences in fiber quality (Colucci et al., 1982; Uden, 1984a, b) in berseem, concentrate, rice straw and maize silage. The results indicate that combining M with B has no effect on CF digestibility, as M and *Mi* are virtually equal (71.7 vs. 71.8). However, Jaakkola (1992) has reported that dilution of forage fiber with less digestible fiber (such as from concentrate or straw) may sometimes cause reduced digestibility. The depression in fiber digestibility might be greater for high quality forage (such as berseem) than for low quality forage, due to a higher content of soluble carbohydrates (Vadiveloo and Holmes, 1979; Jaakkola and Huthanen, 1990). This may have been the reason that C and R had the same CF digestion coefficient, as calculated by the difference method, when mixed with B.

Table 6. Digestion coefficients (%)* of the feedstuffs and the rations

	Exp.1 [i]	Exp.2	Exp.3	Exp.4	Exp.5 [i]	Exp.6 [ii]	Exp.7 [ii]	Exp.8 [ii]	
Feedstuff [iii]	B	BC	BR	BM	M	C	R	Mi	M-Mi
Proximate analysis									
DM	63.7 [a]	64.6 [a]	59.3 [b]	68.9 [c]	69.9 [c]	64.9 [a]	56.5 [d]	71.6 [c]	1.7
OM	65.9 [a]	72.6 [b]	57.3 [c]	69.6 [d]	74.6 [e]	75.0 [b]	51.6 [f]	71.4 [b]	-3.2
CP	73.8 [a]	63.3 [b]	55.6 [c]	68.2 [d]	64.5 [b]	59.1 [e]	15.9 [f]	62.8 [b]	-1.7
EE	66.9 [a]	78.3 [b]	45.2 [c]	65.9 [a]	69.5 [a]	80.0 [b]	17.2 [e]	65.6 [a]	-3.9
CF	56.3 [a]	48.2 [b]	47.3 [b]	67.7 [c]	71.7 [d]	43.2 [e]	44.0 [e]	71.8 [d]	0.1
NFE	69.8 [a]	82.1 [b]	65.0 [c]	71.2 [a]	78.4 [b]	86.0 [d]	61.6 [e]	71.8 [a]	-6.6
Fiber fractions (%)									
NDF	43.8 [a]	46.2 [ab]	49.2 [bc]	46.7 [b]	48.9 [bc]	47.3 [b]	51.3 [c]	48.2 [b]	-0.7
ADF	40.6 [ac]	43.6 [ad]	53.6 [b]	40.8 [a]	38.1 [c]	46.2 [d]	60.0 [b]	41.2 [a]	3.1
Hemicellulose	62.2 [a]	49.7 [b]	38.4 [c]	58.0 [a]	63.2 [a]	48.2 [b]	34.5 [c]	57.2 [a]	-6
ADL	21.6 [a]	20.1 [a]	25.8 [ab]	31.4 [ab]	27.0 [ab]	18.7 [ad]	28.5 [ab]	41.1 [c]	14.1
Cellulose	40.4 [a]	48.0 [b]	55.8 [c]	40.7 [a]	40.2 [a]	53.9 [c]	62.3 [d]	41.2 [a]	1

* a, b, c,.. Means in the same row with different superscripts are significantly different.

i Direct metabolism trials

ii Calculated by difference method from experiments 1,2,3,4 and 5

iii B= Berseem, BC= Berseem + Concentrates, BR= Berseem + Rice straw, BM= Berseem + Maize silage, M= Maize silage, C = Concentrate and R= Rice straw.

Digestibilities of fiber fractions

There was no significant difference ($P<0.05$) between B and M in digestibility of any of the fiber fractions, except for NDF, with berseem having the lower value. In general, the values for legumes, such as berseem are lower than for grasses, such as maize (Van

Soest, 1994). Digestibilities of the fiber fractions of C, R and *Mi* (by difference calculations) were significantly different (P>0.05), except for NDF between C and *Mi*. For the mixtures, NDF and ADL digestibilities were not significantly different for BC, BR and BM, while those for cellulose and hemicellulose were. NDF is indeed known to be more closely associated with intake than with digestibility, because it represents the total insoluble matrix of fiber (van Soest, 1994).

Uden (1984b) and Jaakkola (1992) have reported larger reductions in NDF digestibility of forage with increasing levels of concentrate in hay-fed than in silage-fed cows. On the other hand, when supplementing with high levels of straw, an increase in NDF digestibility was observed (Silva and Orskov, 1988; Nellovu and Buchanan-Smith, 1985; Prasad et al., 1993). Indeed in the present trials, NDF digestibility of BR was higher than of BC or BM.

For ADF, M had the lowest (38.1 %) and R the highest (60 %) digestion coefficient, with C intermediate (46.2 %). This could partly be explained in relation to the corresponding ADF content (Table 3) and intake (Table 4) of M, R and C. The highest ADF content, of which the degradable part is mainly cellulose (Bosch et al., 1991) seems to be associated with the highest ADF digestibility for the individual forages. The same trend was found in BR, BC and BM, with ADF digestibilities of 53.6, 43.8 and 40.8 %, respectively. Digestibility of ADF in M increased (41.2 vs. 38.1 %), when mixed with B. This may have resulted from the more favorable energy/protein ratio for the rumen microorganisms.

Hemicellulose and cellulose digestibilities were almost identical for B and M, while for *Mi* it was 6 units lower than for M. Comparing the data for C, R and *Mi*, calculated by difference, shows that the digestibility of hemicellulose was highest for *Mi*, and lowest for R. For cellulose digestibility, the value for R was highest and for *Mi* lowest. For the mixtures, the digestibilities are ranked BM>BC>BR and BR>BC>BM for hemicellulose and cellulose, respectively.

For ADL, digestibility increased remarkably (14.1 units) when maize silage was mixed with berseem (41%). For the mixtures, BM showed the highest value and BC the lowest. It was expected to find a lower ADL digestion associated with a higher ADL content, because lignin is bound to the cellulose-hemicellulose fraction of the cell wall, and acts as a barrier for enzymatic degradation by rumen microorganisms (Engels, 1987). Therefore, degradation of the cell wall fraction decreases (Bosch et al., 1991) with increased ADL content.

Feeding values

TDN and DCP values (Table 7) are in agreement with the data in the region, and were in descending order C>M>B>R for TDN and B>C>M>R for DCP. When feeding berseem mixed with C total feed intake increased for berseem with concentrates (BC), but forage intake decreased (Jaakkola, 1992; Mould, 1988). This may be related to the density of the concentrates and its NDF content which was negatively correlated (r = -0.56) with DM intake. The observed lower intake of BR may be related to the reduced rate of digestion and passage (Colucci et al., 1992; 1990), both factors that govern the extent of rumen fill.

Table 7. Feeding values of the experimental feeds

	B	BC	BR	BM	M	C	R	Mi
TDN	58.77	66.42	49.15	63.76	69.96	69.32	42.94	61.69
DCP	12.87	10.74	5.57	8.2	5.97	9.93	0.83	6.62

Conclusion

Under the prevailing conditions in Egypt, the fermentation process of maize silage reaches an acceptable range (indicated by the fermentation products) after 16 days of ensiling. Maize silage has neither negative nor positive effects when fed with berseem. Feeding berseem with maize silage increase total DM intake and improve the energy/protein ratio (64%TDN and 12% CP) which allows medium level of milk production.

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Chapter 7

Financial, Nutritional, and Acceptability Assessment of Maize Silage for Small and Medium Scale Dairy Farming

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Financial, nutritional, and acceptability assessment of maize silage for small and medium scale dairy farming

Summary

This paper is one of a series of studies to evaluate maize silage as one of the most promising new technologies/interventions introduced and applied by the Egyptian farmers. The overall goal is to evaluate the maize silage technically, economically and its acceptability by the farmers.
The methodology implemented incorporate results of on-station experiments with animals and interviews of one hundred and fifty-five farmers, spread over 13 villages to collect data, as well as using MDFM (Mixed Dairy Farming Model) which developed by the authors to predict the annual milk production and the nutritional requirements. The costs and returns of cultivating Berseem (B) (Trifolium alexandrinum) as main forage and Maize for silage (M) were calculated using the data obtained from additional survey (17 respondents) conducted in the same villages. While for Rice straw (R) and concentrates (C), the market prices were used.
Eleven different combinations (scenarios) of the four feedstuffs were developed to assess the nutritional feasibility of 9 milk production levels. The scenarios aims satisfy the nutritional constraints and to minimize the feeding cost of the 9 production levels. Sensitivity analyses with regard to the effect of changes in milk price, land rental and labor wages on the margin over feeding costs were performed.
For the acceptability of the maize silage by farmers, the study demonstrated the introduction of maize silage, farmers awareness and the role of extension, response to other new technologies with maize silage, farmer's point of view and finally, the constraints of making maize silage in the study area.
The authors were able to conclude that this study support the hypothesis that nutritional factors represent a major limitation to increase system productivity and profit under conditions in many similar districts in Egypt. In addition the study showed that the farmers' reaction/response toward new technologies is very positive.

Introduction

Mixed farming with livestock complementary to crops is widely practiced in Egypt. Quality and availability of feedstuffs pose problems for the more intensive types of livestock production. Concentrate feeds have no consistent and stable nutrient quality, and whereas low quality roughage such as rice straw is available, its low digestibility limits the use as a source of energy, particularly for milking cows. The wish to increase livestock productivity and farmers' income has led to the introduction and adoption of new technologies in dairy production. Whole maize silage has been one of these innovations that has been introduced to improve quality and availability of forages all year round.

Dairy farming is a commercial enterprise and the objective of farmers is overall profit rather than a contribution to national production (Mainland, 1994). Two objectives from the national viewpoint however, increasing rural incomes and supplying the nation with a balanced diet, run parallel with the farmers' objectives and justify state participation in research and extension.

Animal nutrition research and extension require methods to assess the feasibility of technical innovations (Schiere and De Wit, 1995) before their application under farm conditions. The challenge for the evaluation of new technology is to accurately predict the consequences for environmental, biological and economic characteristics (Congleton, 1984) under a range of physical and market conditions (Bowman et al., 1989; Moll, 1993). The eventual success of the introduction of an innovation is determined by farmers' response, primarily based on the resource requirements, the impact on risk, and on profitability. This response is however a long term process, especially when farmers are not in a position to judge the relevant issues in advance, particularly the production response to new feeds or feed combinations and their impact on costs. Therefore, in the early stages of development and introduction of new technology such as maize silage, considerable benefit could be achieved by undertaking more detailed analysis of the production, its interaction with other components of the diet and its potential impact on the feeding costs and thus on income.

This study provides a two-fold assessment of the inclusion of maize silage in the diet of dairy cows. First, a combination of on-station and on-farm research leads to an assessment of the nutritional and feeding cost aspects at various levels of milk production. Second, the responses of a group of farmers who gained access to the new technology through a development project such as the Food Sector Development Programme (FSDP) provide insight in the acceptability under normal farm conditions.

Methodology

A semi-structured interview with 155 farmers provided data on the actual production of maize silage and berseem in 1997. These farmers were pre-selected through stratified sampling over 13 villages. The selection of individual farmers was based on the following criteria: 1) milk production, farmers should have at least 2 adult dairy animals; 2) silage making, farmers had made silage at least once. In the interviews, the input and output quantities for the two fodder crops were recorded together with prices of land, labour, and other feedstuffs such as rice straw and concentrates. Additionally, questions were asked regarding various aspects related to the acceptability of maize silage.

On-station experiments were carried out to establish the chemical composition and feeding values, as well as the relationship between various feed compositions, that used in this study.

Data on the production and feeding cost of maize silage, berseem, rice straw and concentrates are combined with the relationship between various feed compositions and milk production, to analyse the relationships between optimal feed composition, cost of various rations and feeding, and milk yield levels. Sensitivity analysis with regard to prices of land and labour is carried out to arrive at the least cost combinations of feed compositions and feeding, at various levels of milk yield.

The analysis of the farmers' response to the various aspects related to the acceptability of maize silage provides direct insight in the possibilities and limitations according to farmers' experience in the production and feeding of maize silage.

Feed composition and milk production

The production of maize silage and berseem

Farmers are generally aiming at maximizing the utility of their resources by pursuing a set of multiple objectives. These objectives are conditioned by availability of resources and technology. Utility maximization implies that farmers are likely to adopt new technologies when they enhance the chance of obtaining an acceptable return from the available resources. Under current farming systems, farmers have the choice to produce maize for cash or to make silage to feed their animals, instead of using purchased concentrates. Maize for silage has implications for land resources, labor use and capital requirements. To assess and compare the farm resources related to the production of berseem (B) and maize silage (M), data were analyzed as shown in Table 1.

The data indicate that M needs more external inputs than B; the basic external input needed for M cultivation was almost double that of B (1.9 vs. 1). Adding the conservation costs increased the ratio between M and B to 2.7 : 1 .

To estimate labor requirements, , the current feeding systems is assumed a cut-and-carry system. However, B needs labor to cut-and-carry forages over long distances to feed the animals, while, maize silage is always stored closer to the animal house.

For land, B occupies the land for 7 months compared to 5 months occupation by M. Under irrigated systems, where 2 crops per year are cultivated, the calculation in Table 1 takes into account the length of cropping period in the field. However, relatively, B needs 28%more land than M.

The total costs of production, including feeding, indicate minor differences between B and M.

Table 1. Production and feeding of fodder crops (units per feddan).

	Unit	Berseem	Maize silage
Production			
DM	Ton	5.5	5.6
External inputs			
Fertilizer	£E	179	350
Seed	£E	74	150
Tractor hire (land preparation)	£E	93	142
Chopper hire (maize silage)	£E	0	120
Materials (plastic for maize silage)	£E	0	58
Machinery for baling and transport	£E	0	0
Subtotal	£E	346	820
Labor			
Cultivation	Man day	8	18
Harvesting includes feeding (berseem)	Man day	75	---
Silage making (maize only)	Man day	---	4
Feeding (silage)	Man day	---	36
Subtotal		83	58
Land			
Season length	Month	7	5
Relative land occupation	Feddan/year	0.58	0.42
Cost for production and feeding			
Cash, including 1% interest/month	£E	370	861
Labor, at £E 8 per man day	£E	664	464
Land, at £E 1500 per feddan year	£E	875	625
Total	£E	1909	1950

Financial comparison of feedstuffs

The choice between producing home-grown feeds or purchase feeds from outside, is determined by financial and practical considerations. Practically, maize silage can be produced under local circumstances. However, farmers can reject a new technology for reasons of unknown risks or uneconomic performance or inappropriateness to their resource availability. A simple method compares the unit cost of nutrients as done by Kearl (1982), and Schiere and Nell (1993). This method of cost per unit of nutritive value is simple, but inadequate because it values the energy and protein separately and does not take into account dry matter intake limitations. Comparing the resources required for 1000 £E worth of feed production to purchasing concentrates for 1000 £E, and applying the same concept for feeding values and feeding limitation, would provide a more realistic evaluation. Table 2 represents quantitative and qualitative comparison of producing 1000 £E worth from on-farm produced fodder (B and M) and purchased feedstuffs (R and C).

Table 2. Comparison of fodder production[1,4] and purchased feedstuff for 1000 L£ worth.

	Unit	Berseem	Maize silage	Rice straw	Concentrates
Resources required					
Cash		194	421	654	1000
Labor[1]	Man day	43	30	39	p.m.
Land	Feddan year	0.31	0.21	0.00	0.00
Feeding values					
Dry Matter	Ton	2.88	2.87	13.07	1.48
TDN[2]	Ton	1.69	2.01	5.61	1.02
CP[3]	Ton	0.50	0.27	0.68	0.25
Cost per kg		0.347	0.348	0.077	0.677
Maximum proportion in feedstuff mixture					
Low and medium production levels		0.80	0.65	0.40	0.70
High production level		0.80	0.65	0.00	0.70
Constraint for high milk yield		Low energy High protein	High energy Low protein	High bulking Low energy Low protein	High energy High protein Low bulking
Potential for high milk production level		Medium	Medium	Low	High

[1]Including the required labour to feed the animals

[2]Total Digestible Nutrients, [3] Crude Protein

[4]Prices of land and labour are provided in Table 1

Data indicate that farmers have to match resource availability with quality and quantity of production as follows:

- A relative abundance of land and labor and some cash is required for berseem production. The level of milk production is limited by the energy content of berseem, and only low and medium levels of production are possible.
- Less land and labor combined with more cash is required to produce maize silage. The level of milk production is limited by the protein content, and only low and medium levels of production are attainable.
- No land, but cash and labour only are required for feeding rice straw, but only low milk production levels are possible.
- No land and (hardly) labour, but cash only is required to feed concentrates. Medium and high levels of milk production are attainable with the quality of concentrates as the determining factor.

Nutrition and Milk production

The feeding values, constraints and potentials for high milk production suggest that a combination of the four feedstuffs would lead to a balanced diet from a nutritional point of view (energy and protein) and economic ration formulation.
Calculation of such combinations aims at minimising the feeding cost at different levels of milk production. The prices of the forages were calculated from the direct costs of

Table 3. MDFM[1] predictions of annual milk production and nutrient requirements.

Milk production		Nutritional requirements (annual)		
Daily[2]	Annual	DM[3]	TDN[3]	CP[3]
4	1113	2704	1674	353.3
6	1670	2993	1855	402.4
8	2226	3274	2036	450.8
10	2783	3525	2215	496.2
12	3339	3713	2363	534.8
14	3896	3939	2542	573.9
16	4452	4156	2719	615.7
18	5009	4366	2897	656.6
20	5565	4569	3074	696.7

[1]The state variables in MDFM (Mixed Dairy Farming Model) are: 1)number of days pregnant at the end the year is 220; 2) Body weight is 450 kg, with no gain; 3) animal in the third parity

[2]Daily milk production (kg, at 4% fat) at first month of lactation

[3]DM= dry matter; TDN= total digestible nutrients and CP= crude protein.

fodder production, while for concentrates and rice straw, the market prices were used. The nutritive values applied here, have been determined earlier (Chapter 6, this thesis) by conducting *in vivo* trials. The nutritional constraints require that optimal diets satisfy animal requirements for dry matter, energy and protein. In addition, constraints specify a maximum proportion of each individual feedstuff in the formulated diet. The feeding values and the constraints used are shown in Table 2.

Total annual milk production and nutrient requirements were predicted using the MDFM model (Chapter 4). The state variable was set to fixed values for the animals, except for milk production in the first month of lactation. Predicted milk production, as well as nutrient requirements are shown in Table 3.

Nutritional assessment of the feed mixtures

Feeding scenarios

A number of different combinations of the four feedstuffs were developed to assess the nutritional feasibility at a certain production level (9 levels) as well as the cost of feeding. The nutritional assessment of the 11 possible combinations (scenarios) for the 9 milk production level are summarized in Table 4, and the detailed proportions of the diets, as well as the feeding costs are outlined in Appendix 1.

Table 4. Summary of the feeding situation of different feedstuff combinations and their feeding costs.

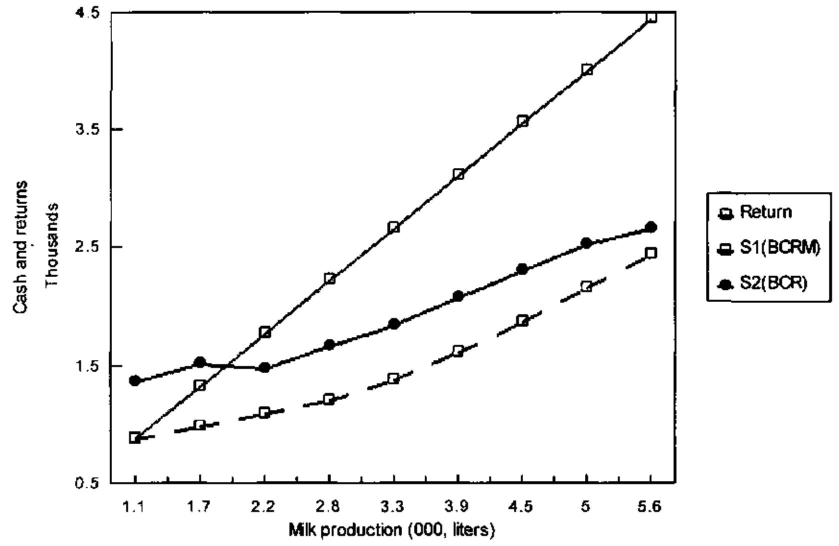
Feedstuff	Feeding situation
Scenario 1	
B+C+R+M	All feeding requirement and constraints satisfied
Scenario 2	
B+C+R	Up to 5000 litre, DM and TDN are satisfied, a surplus is provided of 15% above the total protein required. Above 5000 litre, the same with a surplus of 2% in total DM requirements.
Scenario 3	
C+R+M	For a low production level (1100 litre) all feeding requirements and constraints are satisfied. Above 1100 litre, DM and CP are satisfied, and a surplus is provided of 5% over total TDN requirements. To satisfy CP requirements, concentrates exceed the maximum proportion allowed to maintain healthy condition, being 74, 77 and 79% of DM for animals producing 4450, 5000 and 5560 litre/annum, respectively.

Scenario 4	
B+R+M	Up to 2800 litres, all nutritional requirements are satisfied. At 3300 litre, a small deficiency in TDN occurs, above that level no feasible solution due to high dry matter content
Scenario 5	
B+C	All feeding requirements and constraints are satisfied, with 2% surplus in total TDN requirements. At high production levels (5000 and 5560 litre), concentrates contributed 72 and 81% of the total DM requirements.
Scenario 6	
B+M	Up to 2780 litre, all feeding requirements and constraints are satisfied, with a total TDN supply 10% above requirements. For more than 2780 litre, CP and TDN are satisfied, but DM is 4% higher than the total requirements.
Scenario 7	
B+R	No feasible formulation, using this mixture. Up to 4450 litre, CP was hardly satisfying the requirements, but TDN is less than the requirements at all production levels. The deficiencies ranged from 11 to 17% of the total TDN required. For 5000 and 5560 litre, neither TDN nor CP are satisfied.
Scenario 8	
C+R	Up to 2220 litre, the formulated rations were feasible with small surpluses of DM, TDN and CP of 4, 2 and 1%, respectively. While, no feasible formulation at higher production levels, the deficiencies range from 2 to 9% of the TDN requirements and from 5 to 15% of the CP requirements, for cows producing 2780 up to 5560 litre per lactation.
Scenario 9	
C+M	Feasible formulation occurred with this mixture with a remarkable reverse trend for TDN surplus and milk production level.
Scenario 10	
R+M	No feasible solution for any production level, only DM requirements are covered, while TDN and CP are not satisfied at any production levels.
Scenario 11	
B+C+M	Feasible solutions at all production levels, with surplus of CP for milk production up to 2800 litre.

Optimizing feeding (financial assessment)

The gross returns of milk and the feeding costs of scenarios 1 and 2 are presented in Figure 1. It is clear that scenario 1 (S1) is profitable at all production levels, while S2 becomes profitable when milk production exceeds 2000 litre per year. Moreover, S1 is associated with lower costs, even at high production levels.

Figure 1. Feeding costs and milk return (gross) of different milk production levels



For the other scenarios, S7, S8 and S10 were ignored, because they can not satisfy the nutritional requirements of the animals. S4 and S6 are feasible at lower levels of milk production (up to 2800 litre). The other scenarios are nutritionally feasible but vary in costs.

In general, S1 and S11, which both contain B and M, are the best scenarios with respect to the costs and the potentials for high milk production levels. However, it can be concluded that supplementation of the local forage (berseem) by concentrates at the current milk price (0.8 LE/litre) is unprofitable at low levels of milk production. Use of maize silage is profitable at any production level.

Sensitivity analysis

Two scenarios were selected to perform sensitivity analysis with regard to changes in milk price, land rental rate and labour wages on the cost of feed production, milk return and feeding costs. The first scenario (S1) represents the improved feeding system, including maize silage with berseem, rice straw and concentrates. The second scenario (S2) represents the traditional feeding system, including B, R and C only. The changes in prices lead to changes in ration cost and milk revenue only, not to changes in the ration composition. Hence, in both scenarios the same quantities are used as formulated in Appendix 1.

Response of feed production costs to changes in resource prices

To examine the effect of increasing farm resources prices e.g. land rental rate and labour wages on production costs (including feeding) of B and M, sensitivity analyses were performed by increasing land rental rate and labour wages by 25, 50 and 100% of the current prices. The values of the resources and the response are shown in Table 5.

Table 5. Response of feedstuff costs to changes in resource prices

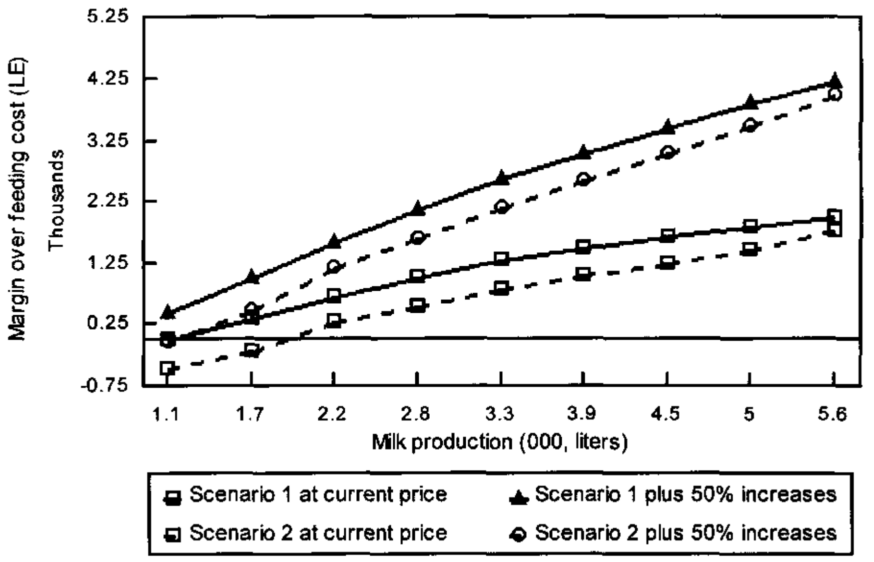
Land		Labour		Feedstuff (LE/Ton)			
Value LE	% increase	Value LE	% increase	B	C	R	M
1500	0	8	0	347	677	77	348
1500	---	10	25	377	677	83	369
1875	25	8	---	387	677	77	376
2250	50	8	---	427	677	77	404
1500	---	12	50	407	677	89	390
3000	100	8	---	506	677	77	460
1500	---	16	100	468	677	101	431
1875	25	10	25	417	677	83	397
2250	50	12	50	487	677	89	445
3000	100	16	100	627	677	101	543

Results indicate that B production is more sensitive than M to changes in resource prices. When price of land rental increases by 25, 50 and 100% the total production costs increases by 8, 16 and 32% for maize compared to 12, 23 and 46% for berseem. The same trends hold for labour wages: total production costs increase by 6, 12 and 24% for maize compared to 9, 17 and 35% for berseem. Increasing the price of both land and labour increases the production costs by 14, 28, and 56 for M and 20, 40 and 80% for B when prices increase by 25, 50 and 100% , respectively.

Response to change in milk price

The response of margin over feeding costs to changes in milk price was examined by increasing milk price by 20 and 50% compared to the current price (Figure 2).

Figure 2. Effect of increasing milk price on the margin over feeding costs



At the current price of milk, net margin is negative, when milk production is low, (-477LE); when milk production increases to 2000 litre the margin becomes zero. A positive margin is realised only when milk production exceeds 2000 litre per annum, which represents the economic level of production at current prices of milk and feeds. The same trends are found for milk price increases of 25 and 50%, the impact being that the economic level of milk production decreases to 1500 and 1100 litre, respectively. For the improved feeding system (S1), increased milk prices have a direct positive impact on the margin over feeding costs.

Response to changes in land price/rental rate

The responses of net margin to increases in land rental rate and labour wages by 25, 50 and 100%, compared to the current prices are presented in Figures 3 and 4.
At current prices, S1 is the only profitable scenario at a milk production of 1100 litre/annum. When the price of land increases by 25, 50 and 100%, profitable milk production level shift to 1700 litre. In the traditional feeding system (S2) the profitable level is 2200 litre, when prices increase by 25 and 50% and 2800 when land price increases by 100%
Similar trends were found when labour wages were increased.

Figure 3. Response to changes in land rental rate

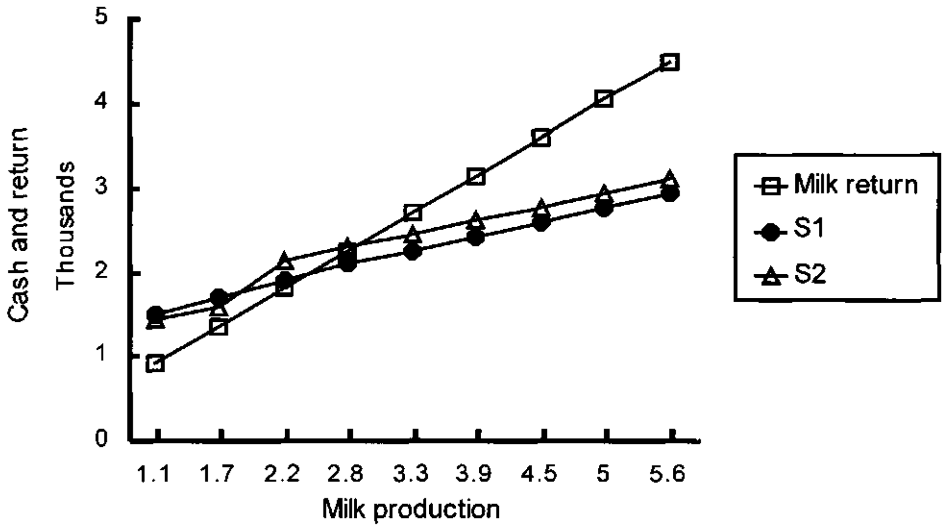
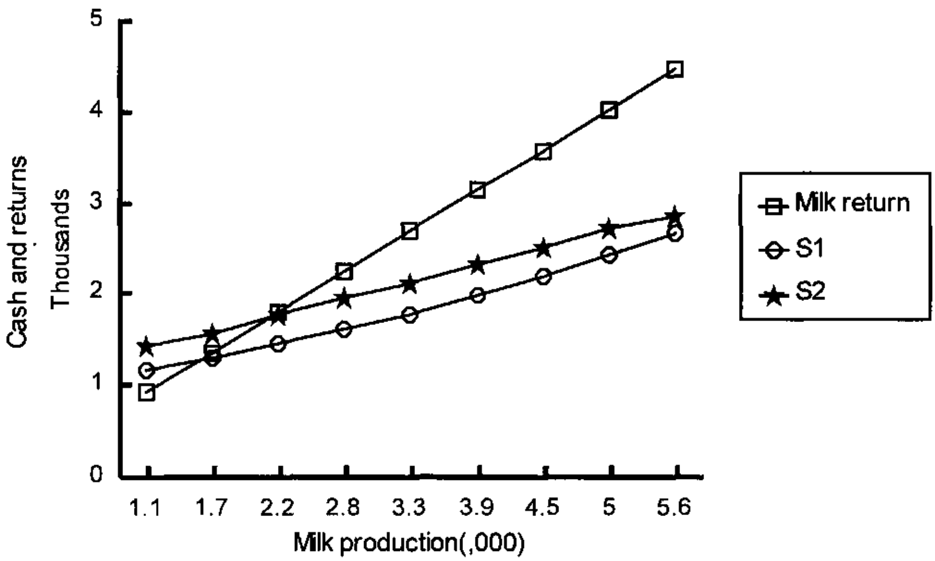


Figure 4. Response to changes in labour wages



Farmers' perspective on maize silage

The measure of acceptance of maize silage by the farmers is an indication for the feasibility of the new technology under normal farm conditions. On the one hand the response of farmers to maize silage can be considered as a tool to check whether the new technologies are suitable for farmers. On the other hand, it can be used as a criterion to judge the extension performance/methodologies from different points of view. Both viewpoints are pursued below.

Introduction and acceptance

At the beginning of 1992, FSDP (Food Sector Development Program, a project funded by EC and the Egyptian government) introduced maize silage making, along with other innovations. Some inputs were subsidized. Before this time maize silage was unknown to most of the farmers. Adoption by farmers of maize silage from 1992 to 1997, as recorded by the area manager of Ashmoun district is shown in Table 6.

Table 6. Number of farmers making maize silage annually.

Item	1992	1993	1994	1995	1996	1997
No. of farmers identified by area manager	7	41	55	159	682	944
Estimated*						2166
No. of farmers receiving support	7	0	0	0	0	20

Source: DSAU, area manager reports

*Estimated is based on the assumption that the number of farmers that can be served by one chopper is 38 (Tabana, 1998)

The data show that the number of farmers who made silage increased substantially over the period from 1992 to 1997. The Area Manager's estimates are considered to be conservative, as they only refer to farmers known to the area manager and his staff. It is estimated that an additional 1222 farmer also made maize silage in 1997 giving a total of 2166. The sample (155 respondents) represents 16.4% of the farmers that identified/reported by the area manager, and 7.2% of the estimated number of farmers that made maize silage.

Extension and awareness

To determine the effectiveness of the extension methodology and the way in which the farmers became aware of maize silage making, they were asked when they first heard about the silage and who supported them in making silage. Table 7 gives the annual breakdown of the number of farmers that became aware of maize silage and the number actually involved in silage making.

Table 7. Number of farmers and awareness (time of hearing) and applying maize silage making for 155 random respondents

Year	Number of farmers that heard about maize silage for the first time	Cumulative number of farmers that heard about maize silage	Number of farmers that made maize silage for first time	Cumulative number of farmers that had made maize silage at least once
83	1	1	0	0
87	1	2	0	0
90	3	5	2	2
91	4	9	2	4
92	17	26	2	6
93	38	64	19	25
94	36	100	31	56
95	30	130	20	76
96	22	152	36	112
97	3	155	43	All respondents*

* Selection of respondents based on making silage in 1997

Before 1992, very few farmers (9) had heard about silage and hardly any (4) had made it. The farmers that had made silage were often also livestock traders, and had seen it being made in different areas where other projects had held demonstrations. They rented locally made choppers from other areas to make silage.

With respect to the contribution of the extension staff in spreading the technology of making maize silage, the data in Table 8 summarize the source of information to the farmers and the relative contribution of the extension staff in spreading information on maize silage. Hence, a relatively large number (108 respondents out of 155, representing 69.7% of the sample) of farmers started learning about the innovation from the extension staff of FSDP. Neighbours (12.9%) or large farmers (11.6%) played a minor role as source of spreading the maize silage package, while other sources such as television programs and projects located in other areas played an insignificant role.

Table 8. Source of information with respect to silage making.

	No. of farmers	%
Extension staff	108	69.7
Neighbour	20	12.9
Innovator (large farmer)	18	11.6
Others	9	5.8
Total	155	100

Introduction and response to other packages

Along with maize silage, other innovations were introduced to the farmers. Table 9 shows the other packages introduced by FSDP extension staff and the number and percentage of farmers interested in applying these innovations. Three extension packages are ranked with a relatively high priority, e.g. mufeed (molasses supplemented by urea, minerals and vitamins; 29%), mixing feedstuffs to produce home-made concentrate rations (26.5%) and artificial insemination (21%). Ammonia and urea treatment seems not to be suitable for this area.

Table 9. Number of farmers applying other innovations, besides maize silage

	Package	Number of farmers	%
Single package	Only maize silage	74	28
Double -packages[1]	M. silage +Mufeed[2]	45	17
	M. silage +AI[3]	33	13
	M. silage +Feed mix	41	16
	M. silage + Ammonia treatment	5	2
	M. silage + Urea treatment	9	3
	M. silage + Hay making	4	2
Treble	M. silage + Mufeed + Feed mix	10	4
	M. silage + Mufeed + AI	24	9
	M. silage + Feed mix + AI	13	2
	M. silage + Mufeed + Feed mix +AI	6	5

[1] some farmers are counted two times when applying more than two packages.
[2] Molasses supplemented by urea, minerals and vitamins
[3] Artificial Insemination

Farmers' point of view

In the interviews, each farmer has given his point of view with respect to the advantages of using maize silage to feed his animals. The questionnaire allowed giving feedback about these advantages recognized, when applying maize silage in the feeding systems.

Farmers have given a multitude of reasons and advantages realized. Table 10 shows these advantages in qualitative and quantitative sense.

Table 10. Advantages recognised by farmers after applying maize silage

Advantage	Number of farmers*	%
Increase in milk and meat production (1)	135	20
Decrease in feeding cost (2)	94	14
Decrease in straw use (3)	53	8
Decrease in labour costs (4)	15	2
Decrease in shortage of fodder between summer and winter (5)	33	5
(1)+(2)	87	13
(1)+(3)	49	7
(1)+(4)	13	2
(1)+(5)	27	4
(2)+(3)	43	6
(2)+(4)	11	2
(2)+(5)	26	4
(3)+(4)	7	1
(3)+(5)	20	3
(4)+(5)	8	1
(1)+(2)+(3)	39	6
(1)+(2)+(3)+(4)	6	1
(1)+(2)+(3)+(4)+(5)	5	1

Source: DSAU, 1998

*Farmers are counted more than one time when they do recognize more than one benefit.

Farmers recognised five single advantages:

a) Most of the farmers (87%) recognised that feeding maize silage has a positive effect on both milk and meat production.

b) A relatively high proportion of the farmers (60%) believed that feeding maize silage reduced feeding costs, as a result of either using smaller amounts of concentrates or using only maize silage without any concentrates.
c) Some farmers (34%), mainly practicing fattening, responded that maize silage reduced the use of wheat straw, which is relatively expensive in their location.
d) A small number of farmers (21%) are making maize silage to fill the gap in fresh fodder availability between summer and winter seasons.
e) A limited number of farmers, who used to hire labour, were responding that using maize silage reduced labour costs, because they tend to feed their animals twice instead of four times as in their traditional feeding system.

Multiple advantages were recognised as:
Double benefits
- Increased production and reduced feeding costs (56%)
- Increased production and reduced straw use (31.5%)
- Other combinations ranged from 4.5 to 27%

Treble and tetra benefits
One quarter of the respondents recognised treble benefits, while a very limited number of farmers recognised more than three advantages of making maize silage as seen in Table 10.

Constraints in Ashmon area

The data in Table 11, show that 59.4% of the farmers did not face any problems in making silage. A range from 6 to 15% of the sample faced different constraints.

Table 11. Constraints in making maize silage in Ashmon area

Constraint	No. of farmers	%
Machine is not available in time	20	12.9
High chopping costs	10	6.4
High labor cost associated with the machine	24	15.5
Not enough fodder to make silage	0	0
No constraint	92	59.4

Conclusion

The results of this study support the hypothesis that nutritional factors represent a major limitation to increase system productivity and profit under the prevailing conditions in many similar districts in Egypt. In addition, the study shows that the farmers' reaction/response to new technologies is very positive.

The diet of berseem with maize silage only (scenario 5) was the best diet from both a nutritional and an financial point of view, followed by a diet, comprising berseem, concentrates, rice straw and maize silage (scenario 1) which is nutritionally feasible, but economically less attractive. Using concentrates was economically not viable at low production levels (below 2000 litre). Using berseem with rice straw can be useful for low-yielding cows. The margin over feeding cost is still positive, even when milk prices would decrease by 25%, if using maize silage or the price of maize silage would become twice as high as the current price.

The financial analysis shows that feed mixtures with maize silage reduce feed cost compared with mixtures without maize silage. This conclusion holds at present price levels for land rental and labor, and for prices that are till 100% above present levels.

Farmers in the project area have quickly recognized the advantage of adding maize silage to the diet of their dairy animals. Their observations focus on higher production levels and lower production costs, which is in line with the step-wise analysis from nutritional and financial viewpoint by the researchers.

Maize silage was well introduced by the extension staff and widely adopted when farmers recognised its advantages.

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Appendix 1. The optimization scenarios of B, C, R and M utilization for different milk production levels with its feeding values and costs at current prices.

Milk pro-	Formulated[2]			Feedstuff[3]				Balance[4]			Feeding
Duction[1]	DM	TDN	CP	B	C	R	M	DM	TDN	CP	Cost[5]
Scenario 1											
1113	2704	1674	353	1376	0	236	1092	0	0	0	876
1670	2993	1855	402	1636	0	207	1150	0	0	0	984
2226	3274	2036	451	1887	0	160	1226	0	0	0	1094
2783	3525	2215	496	2107	0	57	1361	0	0	0	1209
3339	3713	2363	535	2081	279	0	1353	0	0	0	1382
3896	3939	2542	574	1867	751	0	1321	0	0	0	1616
4452	4156	2719	616	1610	1318	0	1229	0	0	0	1878
5009	4366	2897	657	1296	1941	0	1129	0	0	0	2157
5565	4569	3074	697	946	2602	0	1021	0	0	0	2445
Scenario 2											
1113	2704	1674	371	86	1893	725	0	0	0	17	1367
1670	2993	1855	412	108	2095	790	0	0	0	9	1517
2226	3274	2036	563	2214	1060	0	0	0	0	113	1486
2783	3525	2215	605	2166	1359	0	0	0	0	109	1672
3339	3713	2363	636	1999	1714	0	0	0	0	101	1854
3896	3939	2542	672	1787	2152	0	0	0	0	99	2077
4452	4156	2719	707	1535	2621	0	0	0	0	92	2307
5009	4381	2897	744	1325	3056	0	0	15	0	87	2529
5565	4656	3074	791	1458	3198	0	0	87	0	94	2671
Scenario 3											
1113	2704	1674	353	0	1775	764	165	0	0	0	1318
1670	2993	1862	402	0	2095	807	91	0	7	0	1512
2226	3274	2107	451	0	2292	624	359	0	71	0	1724
2783	3525	2452	496	0	2245	0	1280	0	237	0	1965
3339	3713	2581	535	0	2527	0	1186	0	218	0	2123
3896	3939	2738	574	0	2768	0	1171	0	196	0	2281
4452	4156	2888	616	0	3056	0	1100	0	169	0	2452
5009	4366	3033	657	0	3341	0	1025	0	136	0	2618
5565	4569	3173	697	0	3624	0	945	0	99	0	2782
Scenario 4											
1113	2704	1674	353	1376	0	236	1092	0	0	0	876
1670	2993	1855	402	1636	0	207	1150	0	0	0	984
2226	3274	2036	451	1887	0	160	1226	0	0	0	1094
2783	3525	2215	510	2244	0	0	1281	0	0	13	1224
3339	3713	2336	535	2339	0	0	1374	0	-27	0	1290
3896	4027	2542	574	2461	0	0	1566	88	0	0	1399
4452	4311	2719	616	2652	0	0	1659	155	0	0	1497
5009	4594	2897	657	2832	0	0	1762	228	0	0	1596
5565	4875	3074	697	3005	0	0	1870	306	0	0	1693
Scenario 5											
1113	2704	1674	466	1900	804	0	0	0	0	112	1204

1670	2993	1855	515	2083	910	0	0	0	0	113	1339
2226	3274	2036	563	2214	1060	0	0	0	0	113	1486
2783	3525	2215	605	2166	1359	0	0	0	0	109	1672
3339	3713	2363	636	1999	1714	0	0	0	0	101	1854
3896	3939	2542	672	1787	2152	0	0	0	0	99	2077
4452	4156	2719	707	1535	2621	0	0	0	0	92	2307
5009	4366	2897	741	1228	3138	0	0	0	0	84	2551
5565	4569	3074	773	884	3685	0	0	0	0	76	2802
Scenario 6											
1113	2704	1674	409	1946	0	0	758	0	0	56	939
1670	2993	1855	451	2135	0	0	858	0	0	49	1039
2226	3274	2036	489	2274	0	0	1000	0	0	38	1137
2783	3525	2215	510	2244	0	0	1281	0	0	13	1224
3339	3746	2363	535	2302	0	0	1444	33	0	0	1301
3896	4027	2542	574	2461	0	0	1566	88	0	0	1399
4452	4311	2719	616	2652	0	0	1659	155	0	0	1497
5009	4594	2897	657	2832	0	0	1762	228	0	0	1596
5565	4875	3074	697	3005	0	0	1870	306	0	0	1693
Scenario 7											
1113	3101	1674	425	2163	0	938	0	397	0	72	823
1670	3437	1855	471	2394	0	1043	0	444	0	68	911
2226	3776	2036	516	2619	0	1157	0	502	0	65	998
2783	4119	2215	558	2820	0	1299	0	594	0	62	1079
3339	4408	2363	592	2970	0	1438	0	695	0	57	1141
3896	3939	2190	589	3151	0	788	0	0	-352	15	1154
4452	4156	2311	622	3325	0	831	0	0	-408	6	1218
5009	4366	2428	653	3493	0	873	0	0	-469	-3	1279
5565	4569	2541	684	3655	0	914	0	0	-533	-13	1339
Scenario 8											
1113	2736	1674	362	0	1893	843	0	32	0	9	1346
1670	3065	1869	402	0	2095	970	0	72	14	0	1493
2226	3557	2132	451	0	2292	1265	0	283	96	0	1649
2783	3525	2165	470	0	2468	1058	0	0	-50	-27	1752
3339	3713	2280	495	0	2599	1114	0	0	-83	-40	1845
3896	3939	2419	525	0	2757	1182	0	0	-123	-49	1958
4452	4156	2552	554	0	2909	1247	0	0	-167	-62	2066
5009	4366	2681	582	0	3056	1310	0	0	-216	-75	2170
5565	4569	2806	609	0	3198	1371	0	0	-268	-88	2271
Scenario 9											
1113	2704	1883	353	0	1358	0	1346	0	209	0	1388
1670	2993	2083	402	0	1654	0	1339	0	228	0	1586
2226	3274	2278	451	0	1951	0	1323	0	242	0	1781
2783	3525	2452	496	0	2245	0	1280	0	237	0	1965
3339	3713	2581	535	0	2527	0	1186	0	218	0	2123
3896	3939	2738	574	0	2768	0	1171	0	196	0	2281
4452	4156	2888	616	0	3056	0	1100	0	169	0	2452

5009	4366	3033	657	0	3341	0	1025	0	136	0	2618
5565	4569	3173	697	0	3624	0	945	0	99	0	2782
Scenario 10											
1113	2704	1599	207	0	0	1082	1622	0	-75	-146	648
1670	2993	1770	229	0	0	1197	1796	0	-85	-173	717
2226	3274	1937	251	0	0	1310	1964	0	-99	-200	784
2783	3525	2085	270	0	0	1410	2115	0	-130	-226	845
3339	3713	2196	284	0	0	1485	2228	0	-167	-250	890
3896	3939	2330	302	0	0	1576	2363	0	-212	-272	944
4452	4156	2458	318	0	0	1662	2494	0	-261	-297	996
5009	4366	2583	334	0	0	1746	2620	0	-314	-322	1046
5565	4569	2703	350	0	0	1828	2741	0	-371	-347	1095
Scenario 11											
1113	2704	1674	409	1946	0	0	758	0	0	56	939
1670	2993	1855	451	2135	0	0	858	0	0	49	1039
2226	3274	2036	489	2274	0	0	1000	0	0	38	1137
2783	3525	2215	510	2244	0	0	1281	0	0	13	1224
3339	3713	2363	535	2081	279	0	1353	0	0	0	1382
3896	3939	2542	574	1867	751	0	1321	0	0	0	1616
4452	4156	2719	616	1610	1318	0	1229	0	0	0	1878
5009	4366	2897	657	1296	1941	0	1129	0	0	0	2157
5565	4569	3074	697	946	2602	0	1021	0	0	0	2445

[1]Annual milk production in litres

[2]In kilograms, Dry matter (DM), Total Digestible Nutrients (TDN) and Crude Protein (CP) contents of the formulated rations.

[3]Proportional of the formulated feedstuffs; B= Berseem, C= Concentrates, R= Rice straw and M= Maize silage.

[4]Balance between animal requirements and formulated diets, in kilograms.

[5]Feed cost in LE.

General Discussion

General Discussion

This thesis deals with a partial analysis of the possibilities for development of the dairy sector in Egypt. It addresses two interrelated topics. Firstly, it provides an evaluation of maize silage, that has been recently introduced as an intervention in smallholder systems to improve the current feeding situation. Secondly, a model has been developed for the irrigated mixed crop-dairy farm as a decision support tool in optimizing the use of available resources.

On the basis of available information, discussed in this thesis, a general assessment can be made of the current status of mixed crop-dairy farming in Egypt and the scope for future development.

- The dairy sector is the main provider of animal products, but it does not cover the national demand for animal products, the gap between demand and production seems to be continuing for the coming years.
- Feed supply and herd management appear the major technical production constraints. For dairy producers, quantitative and qualitative feed shortages are the major constraints for expansion of herd size and/or transformation to high yielding animals.
- As a consequence, animals are exposed to sub-optimal feeding conditions, i.e. either over or below the requirements.
- The degree of commercialisation (economic objective) is quite high for both crop and animal production. This implies that:
    - The most suitable breed for the mixed farming systems must be a dual purpose breed, allowing farmers to switch easily and with low risks between enterprises (e.g. switching from fattening to dairy and from cash to fodder crops), depending on the market situation.
    - At the current degree of commercialisation, farmers tend to accept new technologies, if economically attractive. These new technologies, leading to production increases, should be accompanied by improvement of existing marketing channels or development of additional channels, through co-operatives and/or NGO's (Non Governmental Organisations).
- For further development, the mixed crop-dairy farming systems should be adapted for regular, non-seasonal production; this requires a year-round optimum feeding regime of cultivated green fodder and conserved good quality forages, if necessary supplemented with concentrates, and proper housing would also be beneficial. Special arrangements will have to be made to meet the technical demands (e.g. housing, milking machines and calf rearing programs) intensive buffalo farming.

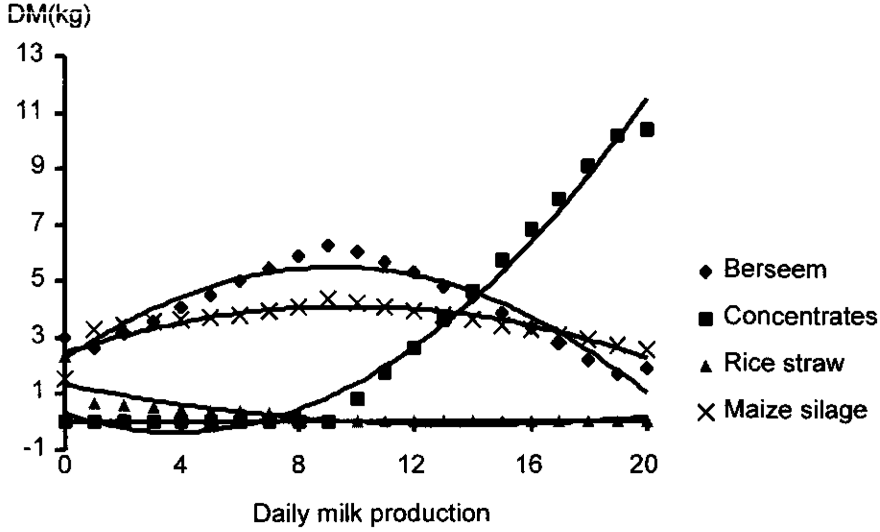
- Maize silage appears a proper technical intervention to arrive at an improved feeding situation; from this study it may be concluded that maize silage has no technical implementation constraints and is easily adopted by farmers.

- Improved farm planning and management procedures by individual farmers, leading to proper allocation of resources and use of improved technology and inputs, are keys to optimising use of available resources.

Implication of making silage

The study has shown that at the current production level of up to 2700 litres per annum or 9 litres per day, a ration consisting of berseem, rice straw and maize silage only, suffices, i.e. there is no need to use concentrates, if maize silage is available. Figure 1 illustrates that a diet of berseem and maize silage only, is sufficient to cover the feed requirements of a cow producing 9 litres/d; below that level, rice straw can be used and above that level concentrates are needed.

Figure 1. Daily feed allowances for dairy animals in the improved feeding system.



For practical implementation, the following equations can be used to formulate the daily ration (Y) in kg dry matter in an improved feeding system, for different milk production levels:

$Y_{berseem}$	$-0.0387X^2$	$+ 0.7905X$	$+ 1.4802$	-----------------------	$R^2=0.90$
$Y_{concentrates}$	$0.0451 X^2$	$- 0.4323X$	$+ 0.685$	-----------------------	$R^2=0.98$
$Y_{rice\ straw}$	$0.0075 X^2$	$- 0.2240X$	$+ 1.549$	-----------------------	$R^2=0.72$
$Y_{maize\ silage}$	$-0.0176X^2$	$+ 0.3763X$	$+ 2.0969$	-----------------------	$R^2=0.82$

Where X= daily milk production (4% fat), for an animal of 450 kg body weight

- Inclusion of maize silage in the local feeding systems leads to rations that are more efficient in terms of nutritional value and economic profitability, and readily accepted by farmers.
- In addition to improving the feeding systems, silage making has direct implications for employment for owners of tractors and operators of choppers. During the time of making silage the tractors are off work, neither used for harvesting nor land preparation. Thus, silage making may contribute to reduced unemployment and/or increased income of tractor owners.
- Using maize silage reduces the labour requirements to feed the animals, compared to the cut and carry system used for berseem.
- Cultivating maize for silage in summer reduces the area required for cultivation of berseem in winter, which means that more land is available to cultivate wheat for human consumption.

Further development of MDFM

In further developing MDFM, attention has to be paid to:
- including new crops, more and different types of animals (e.g. sheep, goat and donkeys) , feedstuffs and interventions
- compilation in the form of software with dialog boxes for easy data entry for use by the local extension staff
- include more farm economics, especially cost-benefit analyses to demonstrate and compare different farm enterprises (e.g. dairy vs. fattening) using formal economic analysis criteria
- translation into Arabic for use by the local extensionists

Overview of the study

- The study is translating the ultimate goal of the national development plan into operational programs and investment projects, which is one of the most critical and difficult tasks facing administrators in the animal production sector especially with for small and medium scale farming.

- The study introduces a new approach of using a computer model as an advisory tool for use by the extension staff at farm level.
- The results of the study provide a framework for evaluation of new technology packages, especially with respect to feeds and feeding packages. Other feeding packages, developed by FSDP should be evaluated in a similar way.
- Due to the large variability in farmers' objectives and environmental conditions, it is difficult to develop effective extension methodologies and formulate extension messages for groups of farmers: the model developed in this study provides the possibility for guidance to individual holders.
- The use of MDFM provides the missing link in the connection farmers-extensionists-researchers, which will finally lead to better understanding of the farming systems and to formulation of research objectives, better geared to farmers' problems.

Implementation of the model

A problem may be the implementation of MDFM implementation in the formulation of long-term plans at provincial and local governorate level by both public and private sectors. The challenge is to provide an adequate joint formulation of planning and implementation in a two-way flow of information between those responsible for further development of MDFM (the researchers) those responsible for the expansion of interventions (the extensionists) and the clients (the farmers).
In practice, three steps should be followed to successfully implement the model:
1) preparation of the extension staff to implement the new technologies
2) intensive training on computer skills and MDFM operation
3) follow up the implementation to make the extend the application domain of the model

Summary

Summary

The study, reported in this thesis, was carried out partly in Egypt and for the other part in The Netherlands. Optimization of resource use in mixed crop-dairy farms in the Nile Delta in Egypt was its objective. It involves two components: (i) modelling the mixed crop-dairy farming system; (ii) assessment of the introduction of maize silage as a technical intervention to improve the local feeding systems.

The thesis starts with a general introduction on the main problems and constraints of animal production in Egypt, followed by a research scheme, that addresses the problems and emphasises potential solutions. In Chapter 2, a classification of animal production systems for Egypt is presented, emphasising the specific role of each system and its potential contribution to development, with special reference to mixed crop-dairy farming systems, which is the target system in this study. In Chapter 3, a detailed analysis/description of the target system is presented, with special attention to the factors/relationships/components that are required for development of a quantitative mathematical model of the system. Based on the qualitative and quantitative description of the mixed crop-dairy farming system, a decision support tool in the form of a computer model is developed (Chapter 4). The model is constructed to simulate activities of a mixed crop-dairy farm for one year, including the introduction of maize silage in the local feeding systems.

The possible role of maize silage was assessed through on-farm trials (Chapter 5), followed by on-station testing, using animals (Chapter 6) and finally, an economic and nutritional assessment, accompanied by an examination of farmers' opinions (Chapter 7). The major findings are summarized below.

Over 70% of the total domestic animal population in Egypt (expressed as animal units on the basis of average live weight, and excluding poultry) consists of cattle and buffaloes. The dairy sector is the main producer of animal products. Currently, Egypt imports dairy products to a value of about 500 million £E (1 £E = 1.4 U$) per annum, representing 43% of the total consumption of dairy products. The mixed crop-dairy farming systems are the most important animal production activity, comprising about 76% of the total animal population, followed by integrated farming systems (17%). Other systems only play a minor role.

The detailed descriptive analyses of mixed crop-dairy farming systems include: cropping calendars of the main agricultural commodities, cropping pattern, herd structure and size, milk and meat production, fertility and animal health, temporal calving distribution, feeding systems and animal nutrition.

The major problems identified, can be summarized as follows: 1) deficiency in forage availability between harvesting periods of successive forage crops; 2) the major constraint for expansion of herd size is the limitation of feed resources; 3) relatively low milk production (compared to pure dairy breeds, such as Friesian); 4) animals are offered unbalanced rations year-round; 5) animals are subjected to sub-optimal conditions by being fed over or below their requirements.

One of the important features is that the mixed farm is a family-owned and -operated enterprise, with a relatively high degree of commercialization (economic objective) in both crop and animal production.
Problem identification, followed by description of the two sub-systems (crop and dairy) formed the basis for development of a farming system conceptual model, that provided the basis for a mathematical computer model.

The Mixed Dairy Farming Model (MDFM) has been developed primarily for use at farm level by extension or management staff. The objective of the model is to analyze present activities of a mixed farm and to maximize its overall profit combining both the crop and dairy component. It also allows testing of biological parameters and management strategies at farm level, to examine their impact on profit.
The model represents 365 days, divided into a 12 (monthly) periods. Simultaneously, it predicts animal production levels, nutrient requirements and cropping pattern based on least cost ration formulation and optimal farm revenues.

Technical evaluation of maize silage included identification of factors that influence subjective and objective silage quality characteristics. The examined factors were 1) length of chopped material; 2) variety; 3) age of maize at ensiling; 4) proportion of ears included in the silage; 5) time from ensiling to opening; 6) off-take feeding period. The effect of each factor was described quantitatively. Good quality silages were generally obtained, indicating satisfactory preservation for all silages. The highest qualities corresponded with whole maize (without removing ears), ensiled at an average age of 108 days, after 17 days of fermentation, and up to 45 days off-take feeding period. Variety and type of chopper used in this study had no significant effect on silage quality. The fermentation characteristics, such as pH, lactic and volatile fatty acid contents, were measured, and visual characteristics monitored. Regression equations, relating fermentation characteristics to the examined factors, generally were characterised by low R^2 -values. It is concluded that silage making was well adopted under the local conditions and the examined factors have insignificant effects on the quality of maize silage produced on-farm.

The nutritional evaluation involved two direct and three indirect metabolism trials with sheep, as the basis for detailed analyses of the development of the fermentation process, and chemical composition of the maize silage, and digestibility, nutritional values and intake of berseem, rice straw, a concentrate mixture and maize silage.
Fermentation is characterised by a fast drop in pH values during the first 8 days, up to 16 days the changes are moderate, while up to 96 days the values vary within narrow limits. After 96 days conservation, total volatile fatty acid (VFA) content was low. Except for acetic and propionic acid, the silage was free from undesirable VFAs, and characterized by high lactic acid content and low pH. Efficiency of fermentation was favourable, as indicated by the ratio of lactate to acetate. With respect to nutrient digestibilities of the four feedstuffs, results indicate that maize silage has the highest DM and OM digestibility coefficients, with no significant differences between maize silage and berseem for the fibre fraction except NDF. Dry matter intake of maize silage was higher than of berseem. Intake of berseem with maize silage was higher than of berseem with rice straw and lower than of berseem with concentrates. Total Digestible Nutrient (TDN) and Digestible Crude Protein (DCP) contents decreased in the order concentrates > maize silage > berseem > rice straw for TDN and berseem > concentrates > maize silage > rice straw for DCP.

The third set of evaluation criteria involved a combination of economic and nutritional characteristics of combining maize silage (M) with B (Berseem), R (Rice straw) and C (Concentrates). The sensitivity of farm profitability to milk price and production costs of maize silage was studied. Moreover, farmer response to farm resource availability and silage making was examined. The study included comparison of eleven rations with or without maize silage (scenarios). The scenarios (S) are: S1 (B+C+R+M), S2 (B+C+R), S3 (C+R+M), S4 (B+R+M), S5 (B+C), S6 (B+M), S7 (B+R), S8 (C+R), S9 (C+M), S10 (R+M) and S11 (B+C+M). The analysis shows that the traditional feeding system (S2, berseem, concentrates and rice straw) is constraining for production of medium or high yielding dairy cows. It indicates that feeding berseem with rice straw does not meet the nutritional requirements of the dairy cows at any production level. Using berseem with rice straw and concentrates increases the production costs by 30%, which means that farmers can make a profit only from cows producing over 2000 litre per year.
The diet of berseem with maize silage only (S6) was the best diet for the low milk production level, from both the nutritional and the economic point of view, followed by the diet comprising berseem, concentrates, rice straw and maize silage (S1), which is nutritionally satisfactorily, but expensive. Using concentrates is economically not remunerative at low production levels (below 2000 litre). Using berseem with rice straw is an attractive alternative for low-yielding cows. The margin over feeding costs is still positive when milk prices decrease by 25%, if maize silage is used, or when the price of maize silage doubles.

The response of profitability of the feeding systems (scenarios) to changes in milk prices indicates that changing the price to 1.2 £E per litre (currently 0.8) resulted in positive margins for all (especially the lower) production levels in all scenarios. At 1.0 £E, the margin was negative at low production levels only (S2, S3 and S4).

At the current farm gate milk price, the margin is positive for S1, S4, S5 and S6 at all production levels, and negative for scenarios S2, S3, S7 and S8 at levels up to 1700 litre per annum.

For milk prices decreasing to 0.6 £E per litre, the margin is positive when berseem and maize silage or rice straw are used (S1, S5 and S6), and negative when using B with C (S2 and S4). When, using C with M and/or R milk production is not remunerative up to 3300 litre (S3, S7 and S8).

The response of feeding costs to increasing the price of maize silage by 20, 40, 60, 80 and 100% at different levels of production was also examined. Margins were positive when the price of M increased by up to 60% of the current price, and negative when price increases exceeded 60%. Using concentrates with maize silage (S8) was more sensitive to changes in maize price and led to negative margins when prices increased by 20%.

Adoption of maize silage by farmers was also examined. The advantages of maize silage as recognised by farmers were: 1) Increased milk and meat production; 2) reduced feeding costs; 3) reduced straw use; 4) reduced labor costs; and finally 5) reduction in shortage of fodder between the summer and winter periods.

Samenvatting

Het in dit proefschrift beschreven onderzoek is deels uitgevoerd in Egypte, deels in Nederland. De doelstelling van het onderzoek was optimalisering van het gebruik van hulpbronnen in gemengde bedrijfssystemen in de Nijl-delta. Het bestond uit twee *componenten: (i) modellering van het gemengde bedrijfssysteem; (ii) evaluatie van de* introductie van snijmaiskuil als een technische innovatie in het systeem om de lokale voersituatie te verbeteren.

Het proefschrift begint met een algemene inleiding, waarin de voornaamste problemen en beperkingen van dierlijke productie in Egypte worden gepresenteerd, gevolgd door een onderzoeksvoorstel waarin de problemen worden geïdentificeerd en oplossingsrichtingen aangegeven. In Hoofdstuk 2 wordt een classificatiesysteem voor dierlijke productiesystemen in Egypte gepresenteerd, met de nadruk op de specifieke rol van elk van die systemen en de mogelijke bijdrage die het kan leveren aan verdere ontwikkeling van de dierlijke productiesector, met speciale aandacht voor het gemengde systeem dat onderwerp is van deze studie. Hoofdstuk 3 bevat een gedetailleerde beschrijving van het gemengde bedrijfssysteem, met speciale aandacht voor de factoren/relaties/componenten die nodig zijn voor de ontwikkeling van een mathematisch model van het systeem. Op grond van de kwalitatieve en kwantitatieve *beschrijving van het gemengde systeem, is* een beslissingsondersteunend systeem ontwikkeld, in de vorm van een computermodel (Hoofdstuk 4). Het model beschrijft de activiteiten van het gemengde systeem voor een periode van een jaar, en bevat de mogelijkheid maissilage in het systeem op te nemen.

De mogelijke rol van snijmaissilage is geëvalueerd middels proeven op praktijkbedrijven (Hoofdstuk 5) en op het proefstation, met inbegrip van voederproeven met dieren (Hoofdstuk 6), en tenslotte is een economische en veevoedkundige evaluatie uitgevoerd, gecombineerd met een onderzoek naar de mening van boeren.

Meer dan 70% van de totale populatie aan landbouwhuisdieren van Egypte (uitgedrukt in diereenheden, op basis van het levend gewicht, en met uitsluiting van pluimvee) bestaat uit rundvee (koeien en buffels). Het grootste deel van de dierlijke productie wordt gerealiseerd door de melkveesector. Op het ogenblik importeert Egypte zuivelproducten met een totale waarde van 500 miljoen £E (1 £E (Egyptisch pond) ~ 1.4 U$) per jaar, *overeenkomend met* 43% van de totale *consumptie*. Het *grootste deel* van de dierlijke productie wordt gerealiseerd in gemengde bedrijfssystemen, die 76% van de veepopulatie omvatten, gevolgd door geïntegreerde bedrijfssystemen (17%). De overige systemen spelen geen rol van betekenis.

De gedetailleerde beschrijvende analyse van het gemengde bedrijfssysteem omvat: de gewaskalenders van de voornaamste gewassen, gewaspatronen, kuddegrootte- en samenstelling, melk- en vleesproductie, vruchtbaarheid en diergezondheid, het temporele afkalfpatroon, voersystemen en diervoeding. De voornaamste problemen die geïdentificeerd zijn, kunnen als volgt worden samengevat: 1) voertekorten in de periode tussen de oogst van twee opeenvolgende voedergewassen; 2) de belangrijkste beperking voor kuddegroei is beperkte voerbeschikbaarheid; 3) relatieve lage melkproducties (vergeleken met die van zuivere melkveerassen zoals Friesians; 4) de dieren krijgen het hele jaar door ongebalanceerde rantsoenen aangeboden; 5) de dieren verkeren dus in sub-optimale omstandigheden doordat ze ofwel boven ofwel onder de behoefte worden gevoerd.
Eén van de belangrijkste kenmerken van het gemengde bedrijfssysteem is dat het een familiebedrijf is, met een relatief sterke marktgerichtheid (economische doelstelling) zowel voor gewasproductie als voor dierlijke productie.
Identificatie van de problemen, gevolgd door beschrijving van de twee sub-systemen (gewas en melkvee) hebben gediend als basis voor de ontwikkeling van een conceptueel model van het gemengde bedrijfssysteem, van waaruit een computermodel is ontwikkeld.

Het Gemengde Bedrijfsmodel (GBM) is in de eerste plaats ontwikkeld voor gebruik op bedrijfsniveau door de voorlichtingsdienst of de bedrijfsleiding. Het doel van het model is om de huidige bedrijfsvoering te analyseren en het bedrijfsresultaat te optimaliseren, gecombineerd voor de gewas- en dier(sub-)systemen. Het model biedt de mogelijkheid biologische parameters te testen, en verschillende strategieën met betrekking tot de bedrijfsvoering te beoordelen, voor wat betreft hun invloed op het economisch bedrijfsresultaat.
Het model beschrijft in totaal 365 dagen, onderverdeeld in 12 (maandelijkse) perioden. Het berekent simultaan dierlijke productieniveau's, voederbehoeften en gewaspatronen gebaseerd op minimum-kosten rantsoenen en maximum-bedrijfsopbrengsten.

De technische evaluatie van snijmaissilage omvatte identificatie van de factoren die de subjectieve en objectieve kwaliteitskenmerken van de silage beïnvloeden. De onderzochte factoren zijn: 1) lengte van het gehakselde materiaal; 2) maisvariëteit; 3) leeftijd van de maïs bij inkuilen; 4) fractie kolven mee-ingekuild; 5) tijd tussen inkuilen en openen van de kuil; 6) lengte van de vervoederingsperiode. Het effect van elk van de factoren op de kwaliteitskenmerken is kwantitatief beschreven. Het bleek dat op alle bedrijven de kwaliteit van het kuilvoer bevredigend was, wijzend op goede inkuilmethoden. De hoogste kwaliteit werd bereikt door een combinatie van inkuilen van de hele plant (inclusief de kolven), op een gemiddelde leeftijd van 108 dagen 17 dagen na inkuilen, en een vervoederperiode tot 45 dagen. Variëteit en type hakselaar hadden in deze studie geen significant effect op de kwaliteit van het kuilvoer. De kwaliteitskenmerken, zoals pH en gehalten aan melkzuur en vluchtige vetzuren zijn gemeten en visuele kenmerken beschreven. De regressievergelijkingen tussen kwaliteitskenmerken en de onderzochte factoren werden over het algemeen gekenmerkt door lage correlatiecoëfficiënten. De conclusie is dat de techniek van inkuilen onder de plaatselijke omstandigheden bevredigend is geaccepteerd, en dat de onderzochte factoren, over de in het onderzoek betrokken range, geen invloed hebben op de kwaliteit van de op het bedrijf gemaakte silage.

De voederevaluatie bestond uit twee directe en drie indirecte voederproeven met schapen, als basis voor een gedetailleerde analyse van de ontwikkeling van het fermentatieproces en de chemische samenstelling van de silage, en van de verteerbaarheid, voederwaarde en opname van berseem (*Trifolium alexandrinum*), rijstestro, snijmaissilage en een krachtvoermengsel.
Tijdens het fermentatieproces daalt de pH snel gedurende de eerste 8 dagen, gevolgd door een langzame daling in de volgende 8 dagen, terwijl daarna, tot 96 dagen, de waarden binnen nauwe grenzen variëren. Na 96 dagen inkuilen was het totale gehalte aan vluchtige vetzuren laag. Het kuilvoer bevatte geen ongewenste vluchtige vetzuren, behalve kleine hoeveelheden azijnzuur en propionzuur, en werd gekenmerkt door een lage pH en een hoog gehalte aan melkzuur. De efficiëntie van fermentatie was hoog, wat bleek uit de verhouding lactaat/acetaat.
Voor de vier voedermiddelen was de verteerbaarheid van de droge stof-en de organische stof het hoogst voor snijmaissilage, terwijl er voor de verteerbaarheid van de ruwvezel geen verschil was tussen silage en berseem behalve voor de NDF-fractie. De opname aan droge stof uit snijmaissilage was hoger dan van berseem. Opname van berseem, gemengd met silage was hoger dan van berseem met rijstestro maar lager dan van berseem met krachtvoer. Totaal verteerbare nutriënten (TDN) en verteerbaar ruw eiwit (vre) verminderden in de volgorde krachtvoer > silage > berseem > rijstestro voor TDN en berseem > krachtvoer > silage > rijstestro voor vre.

De derde set evaluatiecriteria bestond uit een combinatie van economische- en voederwaardekenmerken van het vervoederen van mengsels van snijmaissilage (M), berseem (B), rijstestro (R) en krachtvoer (C). De gevoeligheid van de winstgevendheid van het bedrijf voor veranderingen in melkprijs en kosten van het maken van silage is geanalyseerd.
In de studie werden elf rantsoenen (S) bestudeerd, met en zonder snijmaissilage: S1 (B+C+R+M), S2 (B+C+R), S3 (C+R+M), S4 (B+R+M), S5 (B+C), S6 (B+M), S7 (B+R), S8 (C+R), S9 (C+M), S10 (R+M), en S11 (B+C+M). De analyse laat zien dat de voederwaarde van het traditionele voedersysteem (S2, berseem, krachtvoer en rijstestro) productiebeperkend is voor matig en hoogproductieve melkkoeien. De

voederwaarde van berseem in combinatie met rijstestro (S7) is onvoldoende voor productie. Vervoederen van berseem, gecombineerd met rijstestro en krachtvoer leidt tot een verhoging van de kostprijs van melk met 30%, zodat de boer alleen winst maakt bij een jaarlijkse melkproductie per koe boven 2000 l.

Een rantsoen van berseem met snijmaissilage (S6) bleek het best voor lage melkproductieniveau's, zowel uit het oogpunt van voederwaarde als uit economisch oogpunt, gevolgd door een rantsoen van berseem, krachtvoer, rijstestro en silage (S1), dat toereikend is uit het oogpunt van voederwaarde, maar duur. Het gebruik van krachtvoer is economisch niet aantrekkelijk bij lage productieniveau's (minder dan 2000 l/jaar). Het gebruik van berseem met rijstestro is aantrekkelijk voor laag-productieve dieren. Het economisch overschot, boven de voederkosten is nog positief als de melkprijs met 25% daalt, wanneer snijmaissilage wordt gebruikt, of wanneer de productiekosten van silage verdubbelen.

De respons van de winstgevendheid van de verschillende voedersystemen (scenario's) op veranderingen in melkprijs laat zien dat bij een prijs van £E 1.2/l (vergeleken met 0.8 nu) melkproductie winstgevend is bij alle productieniveau's en alle voersystemen. Bij een melkprijs van £E 1.0/l is het overschot negatief bij lage productieniveau's (S2, S3 en S4). Bij de tegenwoordige melkprijs is het overschot positief voor S1, S4, S5 en S6 voor alle productieniveau's en negatief voor de scenario's S2, S3, S7 en S8 voor productieniveau's tot 1700 l/jaar.

Voor een melkprijs van £E 0.6/l, is het overschot positief wanneer berseem wordt gecombineerd met snijmaissilage of rijstestro (S1, S5 of S6) en negatief wanneer berseem en krachtvoer worden gebruikt (S2 en S4). Wanneer krachvoer wordt gebruikt, gecombineerd met kuilvoer en/of rijstestro, is melkproductie niet winstgevend beneden 3000 l/jaar (S3, S7 en S8).

De respons van voederkosten op toenemende productiekosten van snijmaissilage (20, 40, 60, 80 en 100% hoger), bij verschillende productieniveau's is ook onderzocht. Het overschot bleef positief tot een verhoging met 60%, en werd negatief bij verdere verhoging. Het resultaat bij gebruik van een rantsoen van krachtvoer met snijmaissilage (S8) was gevoeliger voor veranderingen in de prijs van silage en resulteerde in negatieve overschotten bij een prijsverhoging met 20%.

Het onderzoek naar de perceptie van de boeren met betrekking tot snijmaissilage liet zien dat ze als voornaamste voordelen zagen: 1) verhoging van de melk- en vleesproductie; 2) verlaging van de voederkosten; 3) vermindering van strogebruik; 4) verminderde arbeidskosten; en 5) vermindering van de voedertekorten in de periode tussen zomer en winter.

- عدم وجود تأثير هضمي اضافي للسيلاج عند تغذيته مع البرسيم
- تغذيه البرسيم والسيلاج معا يؤدى الى عليقه اكثر اتزانا من ناحيه محتواها من الطاقه و البروتين الخام او المهضوم
- كميه الماده الجافه المأكوله يوميا من السيلاج اعلى من المأكول من البرسيم
- زياده كميه الغذاء المأكول عند تغذيه السيلاج مع البرسيم عنها عند تغذيه البرسيم بمفرده أو البرسيم مع قش الارز.

الجزئيه الاخيره من عمليه التقيم شملت تأثير انتاج الذره لعمل السيلاج على الارض و العماله و رأس المال الازم ومقارنه ذلك بزراعه البرسيم أو شراء مركزات من السوق. وملخص هذا التقيم فى انه فى حاله عدم توافر الارض او العماله مع توافر راس المال فانه من الافضل التوجه نحو زراعه الذره للسيلاج. كما شمل التقيم مدى ملائمه تركيب العليقه للمسويات الانتاجيه المختلفه من الناحيه الغذائيه و الاقتصاديه مع او بدون استخدام سيلاج الذره وخلاصه النتائج ان استخدام سيلاج الذره يخفض من تكاليف التغذيه ويدنى الحد الاقتصادى لانتاج اللبن. الجزئيه الاخيره من عمليه التقيم وهى تشمل وجه نظر المزارعين (الذين قاموا بعمل السيلاج وتغذيه حيواناهم عليه) وعرض ما لمسوه بانفسهم من فوائد و معوقات. من الفوائد التى لاحظها و أقر بها المزارعون بأنفسهم أن التغذيه على السيلاج يزيد من انتاج اللحم واللبن ويخفض من تكاليف التغذيه وتكاليف العماله داخل المزرعه كما يقلل من فتره التغذيه الجافه (مابين مواسم الزراعه) والتى تعد من الفترات الاكثر تكلفه حيث يلجأ المزارعون الى تقديم اعلاف مركزه لتغطيه حاجه الحيوان الغذائيه.

فى المناقشه العامه للرساله تم توضيح انه فى حاله استخدام سيلاج الذره فى التغذيه فان الحيونات الحلابه بمستوى ادرارها الحالى (حتى 8 لتر يوميا) لا تحتاج الى استخدام ايه مركزات كذلك تم اشتقاق اربعه معادلات بسيطه يمكن من خلالها حساب كميات الاعلاف الازمه لكل مستوى انتاجى وهى:

$س_{برسيم} = -0.0387ص^2 + 0.7905ص + 1.4802$ حيث س = كميات الاعلاف الازمه و ص = مستوى الادرار /يوم

$س_{علف مركز} = 0.0451ص^2 - 0.4323ص + 0.685$

$س_{قش ارز} = 0.0075ص^2 - 0.2240ص + 1.549$

$س_{سيلاج} = -0.0176ص^2 + 0.3763ص + 2.0969$

تمت بحمد الله

المزارع. بصفه عامه يقوم البرنامج بعمليه تنبأ للتغيرات التى تحدث للقطيع خلال سنه مقسمه الى 12 شـــهرا متتاليه يقوم خلال بحساب كميه الالبان المتوقع انتاجها وكذلك الزياده فى وزن الجسم والاحتياجات الغذائيــه و تركيب العليقه اليوميه لكل مجموعه متجانسه من الحيوانات بالاضافه الى خطه الزراعه وكميــه الاعــلاف الواجب انتاجها او حفظها او شراؤها من خارج المزرعه وفى النهايه يمكن طباعه ذلك فى تقرير يعطى ملخصـــا للتكاليف والعوائد المتوقعه فى حاله تنفيذ الخطه. وعلى هذا فان هذه الدراسه لا تقدم حـــلا للمشـــاكل فى صوره توصيات مدونه بل تتعدى ذلك حيث انها تقدم برنامج حاسب الى يمكن استخدامه ميدانيا بعد تغـــير مدخلاته بحيث تلائم الوضع الراهن لنظام اداره المزرعه وتقديم التوصيات المثلى حسب امكانيات كل مـزارع على حدى.

الجزء الثانى من الرساله ويتضمن دراسه المعوقات الفنيه والاقتصاديه التى قد ينتج عنها رفض المزارع للتقنيات الجديده وتتلخص النتائج المتحصل عليه فى الاتى:

- التقيم الميدانى لسيلاج الذره والذى شمل دراسه سته عوامل التى قد تؤدى الى انتاج ســـيلاج منخفـــض الجوده أو فساده بعد كمره بواسطه المزارعين وهذه العوامل هى: 1) الاصنـــاف المســـتخدمه 2) عمـــر النبات عند عمل السيلاج 3) نسبه الكيزان التى تركها وتقطيعها مع الحطب لعمل السيلاج 4) طـــول الاجزاء المقطعه (ممثلا بنوع الماكينه المستخدمه فى التقطيع) 5) مده الكمر 6) طول فتره التغذيه منذ فتـــح كومه السيلاج . دلت نتائج التحليل الوصفى (اللون و الرائحه و القـــوام) و المعملـــى للخصـــائص و المركبات المحدده للجوده (درجه الحموضه، حمض اللبنيك، حمض الخليك، حمـــض الـــبروبينيك، حمـــض البيوتريك و الاحماض الدهنيه الطياره الاخرى بالاضافه الى الامونيا) على ان السيلاج المنتـــج بواســـطه المزارعين ذو جوده عاليه بصفه عامه وان افضل النتائج كانت للسيلاج المنتج من نباتات كامله (بـــدون نزع ايه كيزان)، متوسط عمرها 108 يوم وطول فتره التخمر اكبر من 17 يوم ولا تتاثر جوده الســـيلاج منذ بدايه فتح الكومه للتغذيه وحتى مده 45 يوم. ولم يؤدى الاختلاف فى الصنـــف او نـــوع الماكينـــه المستخدمه الى ايه فروق معنويه فى جوده السيلاج. وقد استخلص من ذلك ان سيلاج الذره تقنيه ملائمه للبيئه المحليه وليس هناك من المعوقات الفنيه ما يحد من انتشارها لذلك تقبلها المزارع وطبقها بنجاح.
- التقيم الغذائى لسيلاج الذره شمل دراسه تفصيليه للتخمرات فى مراحل مبكره ومتتاليـــه وقـــد اكـــدت صدقت الدراسه على النتائج المتحصل عليها من الدراسه الميدانيه.كذلك شمل التقيم الغذائى للســـيلاج اجراء تجارب هضم باستخدام الكباش بهدف كشف المزيد من التفاصيل عن عمليات هضـــم المركبـــات الغذائيه وعلاقه ذلك بالقيمه الغذائيه لسيلاج الذره عند التغذيه عليه بمفرده أو مـــع البرســـيم كبديـــل للمركزات او قش الارز. تلخصت النتائج فى الاتى:

- خلال العشره سنوات الاخيره وحتى الان تقوم مصر باستيراد منتجات البان بما يقرب من 500 مليون جنيه مصري سنويا و سيظل الحال على ماهو عليه مالم يتم تنميه نظم الانتاج الحاليه بنسبه تفوق نسبه الزياده فى عدد السكان.
- أكثر من 70% من تعداد الحيوانات المصريه (تم حسابها كوحدات حيوانيه مع استبعاد الدواجن) يتكون من الابقار والجاموس و وتتسم تلك الحيوانات بانتاجيه منخفضه نسبيا.
- حوالى 76% اجمالى الحيوانات (كوحدات حيوانيه) يقع تحت نظام الانتاج الزراعى المختلط (محاصيل- انتاج البان) والنظام الذي يليه فى الاهميه هو نظام الانتاج المتكامل ويمثل حوالى 17% من تعداد الحيوانات وتساهم نظم الانتاج الاخرى بنسب هامشيه.
- التحليل الوصفى و الكمى لنظام انتاج الالبان المختلط والذى تضمن قائمه بالمحاصيل السائده بعد تصنيفها ووصف نظام تعاقبها كما تم التعرض للقطيع من ناحيه حجمه وتركيبه و مستوى انتاجه من الالبان واللحوم و نظم التغذيه الشائعه (لمزيد من التفاصيل يرجى مراجعه الفصل الثالث) أدى الى حصر المشاكل و المحددات التاليه :

- عدم كفايه او ملائمه فى كميه ونوعيه الاعلاف الخضراء المقدمه للحيوانات الحلابه خلال الفترات الانتقاليه (مابين حصاد المحصول السابق وزراعه المحصول اللاحق).
- العامل المحدد لحجم القطيع هو وفره الاعلاف وعلى هذا فان حجم القطيع سيظل ثابتا مالم تتوفر مصادر علف جديده أو تحسين كفائه استخدام المصادر الحاليه
- الانتاجيه المنخفضه من الالبان ترجع الى عدم تغذيه الحيوانات الحلابه على علائق تغطى الاحتياجات الغذائيه بصفه مستديمه، فتاره يحصل الحيوان على اكثر من احتياجاته وتاره أقل مما يؤدى الى نمط انتاجى غير مستقر ومنحنى حليب غير تقليدي.
- من اهم الخصائص المميزه لنظام انتاج الالبان المختلط ان المزرعه تملكها وتديرها العائله بقدر عالى من الاداره الاقتصاديه حيث أن حوالى 70% من انتاج اللبن يتم تسويقه والبقيه يتم استهلاكها بواسطه الاسره او تصنيعها او رضاعتها بواسطه العجول الصغيره.

أهم ما تقدمه هذه الدراسه هو نموذج(برنامج) محاكاه الانتاج الزراعى المختلط ( ) تم تطويره بحيث يتم استخدامه بواسطه الباحثين أوالمرشدين الزارعين. يهدف الموديل الى تحليل الوضع الراهن للمزرعه من الناحيه الاقتصاديه والفنيه فيما يتعلق بنظم التغذيه المتبعه، كما يقدم النموذج الحل الامثل للحصول على اقصى ربح من الانتاج النباتى و الحيوانى ويضمن تغذيه القطيع بطريقه سليمه. يمكن استخدام النموذج لاستعراض و مقارنه العديد من نظم التغذيه اونماذج محصوليه أو معدلات انتاج مختلفه وتأثير ذلك على دخل

الفصل الرابع:

وهو يستعرض اهداف و مراحل تطوير نموذج المحاكاه الذي تم تطويره باستخدام المعلومات والنتائج التى تم التوصل اليها فى الفصل الثالث بالاضافه للمعادلات التى تم تطويرها بواسطه باحثين اخرين. كذلك طريقه و محددات استخدام النموذج. فى نهايه هذا الفصل تم شرح مثال لمزرعه انتاج البان مع استعراض تفصيلى للبيانات الازم ادخالها للحاسب الالى وكذلك البيانات المتحصل عليها بعد تشغيل النموذج وهى تمثل خطه الزراعه للمحاصيل النقديه ومحاصيل الاعلاف كذلك كميه وتوقيت حفظ الاعلاف الخضراء بالاضافه الى الانتاج المتوقع من اللبن و اللحوم و الاحتياجات الغذائيه و التركيب الامثل للعليقه على مدار عام كامل وفى النهايه يستعرض النموذج تكاليف انتاج المحاصيل و تكاليف تغذيه الحيوانات واقصى عائد يمكن الحصول عليه من الاستخدام الامثل لكافه الموارد المتاحه بالمزرعه.

الفصل الخامس

هو تقيم ميدانى لتقنيه عمل سيلاج الذره من الناحيه الفنيه وذلك بأخذ عينات من عدد 155 مزرعه وتم تحليلها تحليلا وصفيا وكيميائيا لتحديد جوده السيلاج المنتج بواسطه المزارعين.

الفصل السادس

وهو يهدف الى دراسه المزيد من التفاصيل عن التركيب الكيماوى للسيلاج وخاصه التى تحدث فى المراحل المبكره لعمليه التخمر بالاضافه الى معاملات الهضم والقيمه الغذائيه لسيلاج الذره بمفرده او كمخلوط مع بعض مواد العلف الشائع استخدامها مثل البرسيم و العلف المركز وقش الارز

الفصل السابع

وفيه تم دراسه تأثير انتاج الذره لعمل السيلاج بدلا من الحبوب ومقارنه ذلك بالبرسيم من حيث الحاجه الى الارض و العماله ورأس المال المستخدم.تم مقارنه نظم التغذيه التقليديه بالنظم المحسنه المقترحه من حيث محتواها من الطاقه و البروتين ومدى ملائمه تركيب العليقه لتغذيه حيوانات عاليه الادرار. تم تقيم اقتصادي باستخدام الاسعار الحاليه لعناصر الانتاج وكذلك عند ارتفاع هذه الاسعار بنسب قد تصل الى الضعف وتاثير ذلك على دخل المزارع من انتاج الالبان. فى نهايه هذا الفصل تم مناقشه درجه استجابه المزارع للتقنيات الحديثه ومعوقات انتشارها من وجهه نظره والفوائد التى لمسها بنفسه عند تطبيقه لتقنيه عمل السيلاج.

فيما يلى ملخص لاهم ما ورود فى الدراسه :

الملخص العربي[1]

تم ءاجراء الأجزاء العمليه من هذه الدر اسه بمصر والأجزاء النظريه والمراجعة النهائيه بهولندا. تهدف هـــذه الدر اسه إلى المسا همه في تطوير قطاع إنتاج الألبان بمنطقه الدلتا عن طريق تعظيم الاستفاده من الموارد المتاحه للمزارع الصغير و المتوسط واختبار مدى ملائمة التقنيات الحديثه للتطبيق على نطاق واسع و تتكون الـــدر اسه من جزأين أساسين:

1 استخدام الحاسب الآلي لتصميم نموذج يحاكى نظم الإنتاج الزراعي القائمه بمنطقه الدلتا وخاصـــة نظـم الإنتاج الزراعي المختلط (محاصيل – ألبان).

2 تقيم سيلاج الذرة كتقنيه حديثه من الناحية الفنية و الاقتصاد يه (سيلاج الذرة إحدى الحزم الفنيــه الى تم تقديمها ونشرها بواسطة برنامج ءانماء قطاع الغذاء بهدف تحسين نظم تغذيه الحيوان) و كذلك تقدير مـــدي استجابة المزارع لتلك التقنية.

و فيما يلي عرض ملخص لمحتويات فصول الرسالة :

الفصل الأول:

يبدأ الفصل الأول بمقدمه عامه عن المشاكل و المعوقات الخاصه بالإنتاج الحيواني بصفة عامه يتبعها توضيـــح لمشاكل انتاج الالبان فى الوضع الحالى والحلول المقترحه لحل هذه المشاكل وتنتهى المقدمه بعـــرض تفصيلـــى للمشروع البحثى الذى تم تنفيذه لاخراج هذه الرساله.

الفصل الثاني:

وفيه تم تصنيف و توصيف نظم الانتاج الحيوانى الشائعه بمصر و اهميه كل نظام انتاجى وامكانيه تنميته لزيـلده مساهمته فى تنميه قطاع الانتاج الحيوانى. بصفه خاصه تم الاسهاب فى توصيف نظام الانتاج الزراعى المختلـط (محاصيل– ءانتاج حيوانى)

الفصل الثالث:

يستعرض نتائج التحليل الوصفى والكمى لنظام انتاج الالبان المختلط مستخدما بيانات عـــدد 36 مزرعـــه موزعه ما بين سته محافظات تمثل منطقه الدلتا وتم متابعتها شهريا لمده ثلاثـــه ســـنوات. تم التركـــيز علـــى المكونات الرئيسيه للنظام (العائله – انتاج المحاصيل – انتاج الالبان) بالاضافه الى العلاقات الكميه والمحددات الازمه لتصميم نموذج حسابى يحاكى نظام انتاج الالبان المختلط بمنطقه الدلتا.

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[1] الملخص العربى ليس بترجمه حرفيه للملخص النجليزى

بسم الله الرحمن الرحيم

تطوير نظام لدعم اتخاذ القرار بمزارع إنتاج الألبان بمنطقة الدلتا

أحمد سعد طبانه