

CELOS bulletins

no. 18

REPORT FOR THE YEAR 1972
of the
CENTRE FOR AGRICULTURAL RESEARCH IN SURINAM

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SCIENTIFIC STAFF

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1. DIRECTOR'S REPORT

1.1. GENERAL

As a result of the revaluation of opinions already mentioned in the previous annual report and the continuously increasing teaching load imposed upon the scientific staff of the Agricultural University of the Netherlands, at CELOS the growth in strength of staff that was characteristic of the previous years gave way to a decline in the year under review. The aggregate number of months the various scientists worked at the Centre decreased from 139 in 1971 to 120. However, the corresponding student figure showed a rise. It increased from 101 in 1971 to 146.

In spite of its smaller scientific staff CELOS continued to spread its wings. The participation in the preliminary investigations carried out in the country's interior developed into an important line of research. It is also regarded as an introduction to a new multidisciplinary research project, still in the planning stage, which will deal with the continuous growing of non-irrigated annual crops on sandy loams and lateritic soils in humid areas. Besides, technical assistance was given to the Government of Jamaica in its efforts to introduce rotation crops for tobacco farms. The results obtained so far are encouraging. Finally mention should be made of collaboration with the newly established Surinam training institute covering the natural, biological and technical sciences.

1.2. SCIENTIFIC STAFF

Ir. R. W. R. Koopmans Ph. D., hydrologist, returned to Wageningen on 14 May, after transferring his duties to Ir. W. H. J. Vochterloo, in Surinam since 17 April.

Ir. C. B. Houtman, agricultural economist, completed the field work of his investigation into the production, marketing and consumption of vegetables and fruit in and around Paramaribo, and left the country on 3 December to resume his duties in the Netherlands.

1.3. STUDENTS

Thirty students of the Agricultural University were attached to the Centre as against 23 in 1971. When their period of practical work was over eight of them carried out research projects for their main subject, viz. crop production, plant breeding, agricultural engineering, water purification or nature preservation. Like in previous years, for many other students posts were found in Government services and private enterprises.

1.4. LAND AND BUILDINGS

During the year under review two drying floors of 12 m² each were constructed. Both are equipped with an oil-fired heater and an electric fan, and can be used for the artificial drying of both, seeds after threshing and the entire crop immediately after harvesting. This welcome addition to the Centre's facilities solves the problems encountered so far because of the frequent occurrence of wet harvesting periods.

1.5. REVIEW OF RESEARCH

The testing of a series of locally fabricated portable irrigation pumps formed the agricultural engineering activities during 1972.

Work in the field of crop botany was limited to two preliminary experiments with cowpea. In one of them fruit setting and pod filling were studied. In the other the relation between leaf area index and dry matter production was investigated.

Crop production research on the other hand was comprehensive. Spacing experiments, part of them undertaken to look into the usefulness of fan designs, were conducted in black and green gram, groundnut, soyabeans, cowpea, sorghum and rice. Groundnut, green gram and soyabeans were also the object of comparative yield trials. The same applies to cassava, but here the age of the crop at harvest is a second variable factor in the experiment. Moreover three herbicide trials, concerned with several (partly pre-emergence) herbicides and various annual crops were carried out. Furthermore, in a preliminary experiment it was investigated whether ridges may serve as a means of growing annual crops on heavy, badly drained soils during wet seasons. Last but not least experiments were started to study the possibilities of growing groundnuts, soyabeans and green gram on the sandy soil south of the country's coastal belt.

Like in previous years entomological research was focussed on the rice borers *Diatraea saccharalis* and *Rupela albinella*, emphasis again being on life history studies of the two species and some of their parasites.

In 1971 a farm management study was started to obtain information on the production of vegetables and fruit in Surinam. Field work continued till August of the year under review. It was followed by processing and analysing the collected data, a tough piece of work that will take at least a full year.

It remained the major objective of forest ecology research begun in 1965 to gather information on succession of the lowland rain forest by recording periodically the vegetation in permanent plots in deforested areas, on land abandoned after shifting cultivation and in exploited and virgin forest. Besides, investigations into the natural propagation of *Cecropia* spp. were continued.

In the field of forestry techniques research was restricted to questions regarding the relationship between man and work in tropical forests. Time and work physiological studies were conducted with regard to weeding young *Pinus caribaea* plantations. As contrasted with the preceding years sophisticated apparatus for the various measurements was available.

The comparative studies with different horticultural and agricultural hand tools started in 1971, were continued. As in the previous year weeding and mowing tools were compared in terms of physical effort involved in using them whereas the weeding tools were also compared for differences in performance.

Hydrology studies were concerned with measuring evapotranspiration by means of a weighable lysimeter and an investigation into the relation between the incoming short-wave radiation and the relative sunshine duration.

Irrigation experiments were started in a citrus plantation on the sandy soils south of the coastal clay zone. It is assumed that additional irrigation may be profitable in this area by neutralizing soil moisture deficits during dry periods.

As part of the study of the production and marketing of vegetables and fruit in Surinam observations were made and traders and customers interviewed at Paramaribo's central market during a 2-month period. In addition a budget study was undertaken amongst

a number of families to investigate the consumer's behaviour in relation to these commodities.

In plant breeding research the study of fruit setting in sweet potato as affected by incompatibility and sterility was continued. Breeding work to arrive at synthetic varieties of maize made further progress, whereas a current selection programme in the same crop yielded hopeful results.

Various experiments dealing with the content and quality of protein in some major tropical food crops were finished. As a result valuable data were obtained on proteins present in crops like sweet potato, sorghum, maize and various pulses.

Silvicultural research comprised the natural regeneration trials dating back to 1965 and 1967, the spacing and thinning trial with *Pinus caribaea*, also dating from 1965, and studies on root morphology and development of *Pinus caribaea* and *Virola surinamensis*.

Work in the field of soil fertility and plant nutrition covered such topics as the use of maize for the assessment of sufficiency quotients, a soil fertility survey of some soils in the interior of the country, an evaluation of the productivity and fertilizer needs of the various soils in a recently opened experimental garden, the effect of split-application of fertilizers in maize, and experiments concerned with laboratory procedures.

This year upland rice (long wet season) followed by maize and soyabeans (long dry season) were grown in the long-term fertility trial started in 1970 to study the effect of tillage and minimum tillage on a heavy coastal clay soil under permanent cropping. A similar trial started in 1971 on a light sandy soil in the savannah zone of Surinam was continued in a somewhat modified form with various annual crops.

1.6. CONTACTS

Among the authorities and scientists visiting CELOS were Mr. J. de Visser, registrar of the Agricultural University of the Netherlands, and several groups of lecturers and students from the Faculty of Agriculture of the University of the West Indies (St. Augustine, Trinidad).

Within the framework of the Dutch technical aid programme, Dr. Ruinard, Dr. Wienk and Dr. Van Marrewijk visited Jamaica (from 26 January to 5 February, 16 to 27 April and 31 July to 9 August respectively) to assist in introducing rotation crops on tobacco farms.

Mr. G.W. Cellarius, a post-graduate student, Ir. Houtman and Dr. Van Marrewijk attended the Seminar/Workshop on Horticultural Development in the Caribbean held in Maturin (Venezuela) from 13 to 18 March, and visited the Faculty of Agriculture of the University of the West Indies from 19 to 22 March.

From 5 to 8 April Dr. Ruinard was in Trinidad for consultations with officials of the University of the West Indies, and from 5 to 15 November in Wageningen to discuss policy and financial matters regarding the Centre.

Dr. Wienk was in Wageningen from August to December to make preparations for a new multidisciplinary research project; for the same purpose he visited the International Institute of Tropical Agriculture in Ibadan (Nigeria) from 9 to 23 December.

1.7. PUBLICATIONS AND REPORTS

The following CELOS Bulletin was published :

16. Report for the year 1971 of the Centre for Agricultural Research in Surinam (English; Portuguese and Spanish summaries).

Like in previous years mimeographed "CELOS Quarterly Reports" and "CELOS Reports", both in Dutch, were issued. The latter comprised the numbers 61 to 79 inclusive and dealt with various silvicultural and forest ecological topics, work studies in the field of forest exploitation, growth analytical work in rice and cowpea, variety trials with peanut and cowpea, investigations into mechanized tillage and cultivation practices, miscellaneous studies on the rice borers *Diatraea saccharalis* and *Rupela albinella*, several hydrological topics, soil fertility assessment, inheritance of some seed coat characteristics in cowpea, a morphological description of a large number of cassava clones, and the marketing and consumption of vegetables and fruit.

1.8. ACKNOWLEDGEMENTS

We are greatly indebted to Dr. José H. da Costa Ferreira for translating the summary of this annual report into Portuguese.

JR

2. AGRICULTURAL ENGINEERING

2.1. TESTING TRANSPORTABLE IRRIGATION PUMPS (72/15)

In co-operation with the manufacturer a number of transportable irrigation pumps were tested for water output, power required and efficiency. The pumps consist of a 4.5 m long tube with a diameter of 12", 14" or 16". Through this tube runs a shaft at the lower end of which a propellor and at the upper end of which a pulley is mounted. The shaft is driven from a tractor by means of belt. The pumps are working at a tube's angle of about 45°.

In the tests the water was lifted from 70 or 190 cm. The r.p.m. of the propellor shaft was varied from 600 to 1000. The propellers of the different pump types were over-sized ship propellers and had three blades of which the tips had been removed; for example, the 12" pump was fitted with a propellor of 15" diameter. Furthermore a new type of propellor was tested which was constructed with a bigger blade surface than the ones normally used. Pump, blade and propellor types are summarized in Table 1.

Table 1 - Pump and propellor types tested

Pump	Propellor*
Vadini 12"	MP 14" x 17"
" 14"	MP 16" x 17"
" 16"	DJ 18" x 17"
" 14"	VD 14"***
" 16"	VD 16"***

- * MP and DJ propellor type (factory indication)
14" x 17": diameter and pitch of propellor respectively.
- ** Modified propellers.

The water output was measured by a rectangular weir. The power needed to drive the pump was obtained from the relation between the fuel consumption of the tractor engine and its power output, this relation being determined by a water brake at varying r.p.m. The efficiency was computed with the formula

$$E = \frac{Q \times H_{tot} \times sg}{3600 \times 75 \times N} \text{ where}$$

- E = efficiency of pump and belt transmission;
- Q = water output (m³/hour);
- H_{tot} = total lifting height (m) = static plus dynamic lifting height;
- sg = specific gravity of the water (kg/m³);
- N = power needed (h.p.).

Generally the efficiency increased with increasing r.p.m. and with decreasing lifting height. However, with the modified propellers the range in efficiency was less than with the ship propellers. As the pump is normally used at a shaft speed of 800 r.p.m.

only the results at this number of revolutions are reported here (Table 2). The highest measured efficiency was 45%. This was obtained at 800 r.p.m. with a 14" pump fitted with a normal propellor and operating at a lifting height of 70 cm. The maxi-

Table 2 - Water output, power requirement and efficiency of different pump types*) at 800 r.p.m. and lifting heights of 0.70 and 1.90 m

	pump type					
	12"		14"		16"	
	0.70	1.90	0.70	1.90	0.70	0.90
a. fitted with normal propellor						
output (m ³ /hour)	420	95	715	250	880	505
power (h.p.)	8.0	13	8.5	15	12	20
efficiency (%)	22	5	45	13	39	21
b. fitted with modified propellor						
output (m ³ /hour)			650	415	995	690
power (h.p.)			9	15	14	22
efficiency (%)			37	24	42	28

* Their construction under local conditions being the primary object the efficiency of these pumps is only moderate.

imum measured outputs of the 12", 14" and 16" pumps fitted with a normal propellor were 700, 1005 and 1210 m³/hour respectively whereas for the 14" and 16" pumps fitted with a modified propellor outputs were obtained of 965 and 1370 m³/hour respectively. These figures were found at 100 r.p.m. and at a lifting height of 70 cm. The output of the pumps was less affected by lifting height when fitted with modified propellers than with normal ones.

TS

3 CROP BOTANY

In this discipline little work was done during the year under review. Two preliminary experiments were carried out with cowpea. In the one fruit setting and pod filling were studied, in the other it was attempted to investigate the relation between leaf area index and dry matter production.

3.1. FRUIT SETTING AND POD FILLING IN COWPEA AS AFFECTED BY THE POSITION OF THE FLOWERS AND BY THE TIME OF ANTHESIS (72/3)

In a preliminary pot experiment with cowpea position and date of anthesis were recorded for the individual flowers of the cultivars African Red, PI 221731 and Blackeye. The first two are determinate, upright cultivars, the last one is semi-upright whereas its growth tends to continue after flowering. At maturity the position and the ratio seeds: ovaries for each pod were noted.

In African Red and PI 221731 about three quarters of the total number of open flowers formed appeared to belong to the first pair of an inflorescence, the remainder to the second one. In Blackeye only 5% belonged to the second pair. The number of pods per inflorescence in Blackeye and PI 221731 was never higher than two, whereas in African Red 6% of the inflorescences bore three pods.

The total number of open flowers per plant on any day was for all three cultivars highest on the fifth or sixth day after plants had commenced flowering.

Generally, the percentage fruit setting and the ratio seeds: ovaries were highest for the first flowers and the first pods respectively. African Red and PI 221731 bore most pods on the main stem inflorescences whereas Blackeye had more pods on its laterals. However, in this cultivar pods on the main stem were better filled.

3.2. DRY MATTER PRODUCTION IN *Vigna unguiculata* (L.) WALP. cv. AFRICAN RED AS AFFECTED BY LEAF AREA INDEX (72/4)

Under field conditions differences in crop growth rate at various spacings may, apart from light competition, be attributable to differences in water and nutrient supply. To study the effect of leaf area index on dry matter production in the cowpea cultivar African Red plants were grown in pots so that the amount of soil per plant was kept constant. The pots were arranged in the spacings 15 x 15 cm and 30 x 30 cm.

From daily sampling for a period of 18 days starting 17 days from sowing there appeared only slight differences in total plant weight. Growth was virtually linear. Straight lines fitted to the treatment means yielded regression coefficients of 0.31 and 0.36 g/plant/day for the narrow and wide spacing respectively. However, variation was rather large so that the daily differences were sometimes significant sometimes not. Leaf area per plant hardly differed at both beginning and end of the sampling period but consistent differences were found in the period between, indicating a rather large variation as well.

Mathematically dry weights at both spacings diverged at about the time sampling commenced, the differences being of little practical significance, however.

Though differences in dry weight between spacings were very small, plant shape was markedly affected. At the narrow spacing the plants were taller and had less laterals but a larger percentage of the total dry weight had accumulated in the stems. As for

leaf weight the opposite occurred, the leaves being thicker at the wider spacing.

That no clear-cut differences were obtained may suggest that under field conditions water and nutrient supply play an important role in inter-plant competition.

JFW

4. CROP PRODUCTION

4.1. SPACING EXPERIMENTS

A number of spacing experiments were conducted during the period under review. The crops concerned were black gram (*Phaseolus mungo* L.), rice, sorghum, groundnut, soyabeans, cowpea and green gram (*Phaseolus aureus* ROXB.). The experiments with the last four crops comprised plant density and plant arrangement trials comparing randomized with systematic designs. In the first two crops the effect of plant density on yield was studied.

4.1.1. BLACK GRAM (71/19)

During the long dry season of 1971 a randomized block experiment with four replications was planted to investigate the effect of plant density on yield of black gram. Three spacings were compared, viz. 20 x 20, 30 x 30 and 40 x 40 cm.

Because of periods of extremely wet weather crop growth was rather irregular and many plants were missing, resulting in large variations in and between replications. Harvesting had to take place in a few rounds. Yields at 12% moisture content were at the rate of 1.82, 1.44 and 1.53 ± 0.16 tons/ha for the spacings 20 x 20, 30 x 30 and 40 x 40 cm respectively. There were no statistical differences between these figures. Neither 1000-grain weight nor the shelling percentage was affected by spacing.

JFW

4.1.2. RICE (72/8)

During the long rainy season of 1972 a plant density trial was conducted to compare the cultivars Acorni and IR 8 at three different spacings. Acorni has been selected for mechanized rice growing including broadcasting whereas IR 8 was developed for traditional agriculture where transplanting is used. Three spacings were compared in a randomized block experiment with four replications: 10 x 10, 20 x 20 and 30 x 30 cm.

Differences in tillering between Acorni and IR 8 soon became evident. At comparable spacings IR 8 always had more tillers than Acorni, the difference becoming larger as the spacing increased. Differences between spacings appeared at about 7 weeks from sowing when tillering at the highest density had already reached a maximum. The wider the spacing the longer tillering continued.

IR 8 flowered somewhat earlier than Acorni. The wider the spacing the later flowering within a cultivar. Acorni is a taller plant than IR 8. Although spacing had no significant effect on plant height IR 8 tended to be shorter at closer spacings whereas Acorni showed the opposite effect. Panicle length was not affected by spacing either.

At harvesting the number of productive panicles per plant at the closest two spacings was the same for Acorni as for IR 8. At the widest spacing Acorni had distinctly less tillers than IR 8. The difference in number of productive panicles between the two cultivars was less than in number of tillers owing to a larger percentage of completely sterile panicles in IR 8. This percentage decreased with decreasing density.

Spacing had a marked effect on the number of productive panicles per unit area (Table 3). In both cultivars this number was higher at the closest spacing. For IR 8 there were no statistical differences between the widest two spacings but for Acorni the number of panicles sharply dropped as the density decreased. Generally IR 8 had more panicles per unit area than Acorni.

Table 3 - Some yield data from a comparison between the rice cultivars IR 8 and Acorni at three different spacings. Weights at 12% moisture content

	productive panicles/m ²	grain yield per		
		panicle (g)	plant (g)	hectare (tons)
IR 8	±10	±0.05	±2.2	±0.34
10 x 10 cm	283	2.16	6.6	6.10
20 x 20 cm	218	2.69	28.3	5.84
30 x 30 cm	204	2.88	53.2	5.88
mean	235±6	2.58±0.03	28.4±1.3	5.94±0.20
Acorni				
10 x 10 cm	273	2.21	7.0	6.03
20 x 20 cm	218	2.90	26.2	6.28
30 x 30 cm	159	3.35	47.7	5.30
mean	217±6	2.82±0.03	27.0±1.3	5.87±0.20

In both cultivars grain yield per panicle increased with decreasing density as did grain yield per plant. However, between the widest two spacings the increase in yield per plant was not proportional to the increase in area per plant. But the discrepancy was greater for Acorni than for IR 8.

Average yields per hectare did not differ between cultivars: 5.94 and 5.87 ± 0.20 tons at 12% moisture content for IR 8 and Acorni respectively. The yield differences observed between spacings were not statistically significant.

JFW

4.1.3. SORGHUM (72/25)

A trial was set up to obtain information on the optimal plant density on soils of the Coesewijne formation. The experiment was laid out in four complete blocks, two on unbleached sand and two on sandy loam. Each block contained three open-pollinated varieties, i.e. Martin, SB 65 and SB 79, at four spacings, viz. 90 x 30, 60 x 30, 90 x 15 and 60 x 15 cm. Plots were 4.50 x 5.40 m and the number of plants per plot, depending on the spacing, varied from 90 to 270.

No tillage took place. The cover of tropical kudzu present on the experimental site was cut and sprayed twice with Gramoxone. The soil was limed with Emkal at the rate of 3000 kg CaCO₃/ha.

Emergence was very poor. Martin did not germinate at all. Of the other two varieties germination was reasonable, but many seedlings soon died upon emergence. After two infillings average percentages of occupied planting hills were found of about 25 on the sand and 30 on the sandy loam. This dying of very young seedlings was also observed in former trials on sandy soils, but proved to be completely absent on clay soils. The cause of this is as yet unknown.

Though the trial as such was a failure observations were continued. Surviving plants tillered strongly and were free from pests and diseases. Only at the end of the growing season an attack of anthracnose (*Colletotrichum* sp.) was recorded in the plots on sand.

Kernel yields ranged from 620-1010 kg/ha on sand and from 1150-2490 on sandy loam despite low plant densities. On both soil types SB 65 was less productive than SB 79. Evaluation of the data obtained led to the tentative conclusion that sandy soils are unsuitable for growing sorghum, whereas on sandy loam a density of about 40,000 plants per ha is likely to be the maximum.

GAM

4.1.4. GROUNDNUT, SOYABEANS, COWPEA AND GREEN GRAM (72/30-72/33)

In Surinam's traditional agriculture crops like groundnut, soyabeans, cowpea and green gram are planted at a spacing of about 30 x 30 cm, i.e. at 111,000 plants/ha. With a view to mechanical cultivation two questions need answering. In the first place it is wondered whether the traditional spacing is the optimum one. Secondly it may be questioned whether within this population plant arrangements are possible that do not interfere with mechanized inter-row cultivation and that have no harmful effect on yield.

During the long dry season of 1972 a series of density and spacing experiments were conducted with the aforementioned crops. To be able to compare a range of densities and plant arrangements NELDER's*) fan design was used. For comparison also a number of complete randomized block experiments were laid down in which some selected densities or spacings were investigated. Plant density experiments of both designs and randomized arrangement trials were conducted in all four crops, whereas systematic arrangement experiments were only carried out for cowpea. A single cultivar was used for the various crops.

Plant densities in the systematic experiments (72/30) ranged from 37-300 x 10³ plants/ha for each of the crops investigated. In the randomized block experiments (72/31) three densities were compared, i.e. 62.5, 111 and 250 x 10³ plants/ha. The plant arrangements in these density trials were all square.

In the systematic plant arrangement trial (72/32) the cowpea was planted at a density of 111,000 plants per hectare, rectangularities varying from 1.00 to 4.01. The randomized block experiments (72/33) for all crops compared three spacings, viz. 30 x 30, 45 x 20 and 60 x 15 cm. In the case of soyabeans, groundnut and cowpea also the double-row arrangement (15 x 30) x 45 cm was included whereas for cowpea two extra spacings were added in the form of 40 x 22.5 and 50 x 18 cm.

The unfavourable weather conditions prevailing through most of the growing season adversely affected crop growth so that plants did not always reach an optimum size and yields generally remained below average.

In the systematic plant density trials the yield of groundnut hardly appeared to be affected by differences in number of plants per hectare. Yields were low and varied somewhat around 700 kg/ha. In cowpea and green gram there was a tendency for the yields to decline with decreasing density. Yields were highest at the highest density. Maximum yields obtained were around 1600 kg/ha for cowpea and about 1300 kg/ha for green gram. Lowest yields were about 1000 and 700 kg/ha respectively.

For green gram the yields from the randomized block experiment closely agreed with those obtained in the systematic trials. The yields of groundnut only agreed well for the lowest and highest density but not for the intermediate one. At this density a

*) NELDER, J. A., 1962. New kinds of systematic designs for spacing experiments. *Biometrics*, 18: 238-307.

yield of nearly 1100 kg/ha was obtained. Poor growth of the cowpea made comparison impossible. Emergence of the soyabean in the systematic experiment was so bad that this trial was abandoned. In the randomized block experiment soyabean yields declined with decreasing density.

In the systematic plant arrangement trial with cowpea yields varied somewhat irregularly between 1100 and 1300 kg/ha. There were no consistent differences between rectangularities of spacing. In the randomized block experiment cowpea yields were rather low. Though differences between arrangements were sometimes significant, they were inconsistent so that no clear picture could be obtained. For green gram and groundnut no differences were found. Yield levels for these two crops were 600-700 and 1500-1600 kg/ha respectively. Generally the results indicate that the cultivars used are rather flexible as far as spacing is concerned.

JFW

4.2. COMPARATIVE YIELD TRIALS

4.2.1. CASSAVA (71/4)

Following a two-year period (1969-1971) of intensive observations in a cassava collection of local and foreign introductions, nine clones were eventually selected. They had shown a relatively good performance under the conditions prevailing at the Centre.

The selected clones were planted in February, 1971 on three cambered 6-m beds. Plots consisted of 7 x 3 plants spaced 1 x 1 m. The lay-out was such that if no guard rows were considered the clones were arranged in unbalanced incomplete blocks replicated six times, whereas with guard rows the trial would be of a balanced incomplete design with four replicates. Tillage was confined to shallow hoeing to control weeds. To avoid lodging, which was a serious problem in former plantings, no fertilizer was applied.

Root production was very low and variable (see Table 4). Average production per plant was between 0.17 and 3.0 kg, which equals 1.7-30 tons ha. The over-all average was 0.95 kg/plant or 9500 kg/ha.

Table 4 - Root production (kg/plot; fresh weight) of nine cassava cultivars

clone	origin	replication						total
		I	II	III	IV	V	VI	
Indische Stok	Surinam	21.1	3.8	18.6	6.1	19.7	15.9	85.2
Zoet 2	"	9.0	21.7	6.2	4.1	9.1	12.4	62.5
Bitter IV	"	27.3	13.7	12.4	12.7	17.6	44.3	128.0
Bitter V	"	26.4	12.2	10.3	23.5	5.7	63.2	141.3
Basiorao	Brazil	12.1	32.1	28.9	23.1	19.5	20.4	136.1
2062	Venezuela	35.2	3.5	42.5	23.4	15.7	24.3	144.6
2106	"	19.5	6.5	8.7	44.7	30.3	26.7	136.4
2171	"	13.7	14.3	20.6	13.7	23.6	16.6	102.5
2195	"	17.9	11.0	26.5	27.9	41.0	20.5	144.8
Total		182.2	118.8	174.7	179.2	182.2	244.3	1081.4

If the results are analysed as a 3x3 balanced lattice significant differences only exist between Zoet 2 and Basiorao, Zoet 2 and 2062, Basiorao and 2171, and 2062 and 2171. On using all six replicates in the analysis more significant differences are found. All clones, except Zoet 2, are better than 2171. Zoet 2 produces significantly less than Bitter IV, Bitter V, Basiorao, 2062 and 2195. The large variation is responsible for the poor results of statistical analysis.

The supposition that the clay soils of the coastal belt are unsuitable for cassava growing is supported by the results of this experiment.

GAM

4.2.2. GROUNDNUT (72/27)

A comparative yield trial was conducted during the long dry season. The cultivars were B 719 and 47-56 introduced from Nigeria and Matjan of local origin. They all mature in about 100 days. The trial was of the randomized complete block design with six replicates. The yields and some yield components are presented in Table 5.

Table 5 - Pod and seed yields (tons/ha; 12% moisture), 1000-grain weights (g) and shelling percentages for three groundnut cultivars

cultivar	yield		1000-grain	shelling
	Pods	seeds	weight	percentage
	± 0.09	± 0.07	± 6	
B 719	1.50	1.08	503	72
47-56	1.64	1.17	395	71
Matjan	1.91	1.37	508	71

As in previous comparative trials Matjan outyielded the other cultivars though the difference with 47-56 was not statistically significant. In spite of its comparatively large seeds B 719 yielded distinctly less than Matjan, indicating that it combines a low pod number with large seeds. In 47-56 the small seed size was not offset by a large number of seeds although pods contained up to four seeds.

Yields were generally low. Unfavourable weather conditions in combination with a less suitable soil may explain these results.

JFW

4.2.3. GREEN GRAM (72/28)

Five green gram cultivars were compared during the long dry season in a randomized complete block experiment with six replicates. The cultivars used were 68002, 68007, Oklahoma, Trinidad Mung and Jumbo Mung 1000 R. 68002 is of Indian origin, Oklahoma was introduced from the U.S.A. and the remainder were locally obtained. Some yield data are presented in Table 6.

Yields were low as a result of unfavourable weather conditions during most of the growing period. No differences in terms of pod or seed yields were found between cultivars though Jumbo Mung 1000 R tended to produce more than the other ones. 68002 had the largest seeds but this characteristic apparently was combined with a low seed number.

JFW

Table 6 - Pod and seed yields (kg/ha; 12% moisture), 1000-grain weights (g) and shelling percentages for five green gram cultivars

cultivar	yield		1000-grain	shelling
	Pods	seeds	weight	percentage
	±95	±59	±0.2	
68002	939	659	52.2	70
68007	957	656	38.6	69
Oklahoma	940	638	33.0	68
Trinidad Mung	964	627	37.8	65
Jumbo Mung 1000 R	1197	794	39.9	66

4.2.4. SOYABEANS (72/29)

During the long dry season the yields of four soyabean cultivars were compared in a randomized complete block experiment with six replicates. The cultivars were Laris, H.L.S. 154, Light Speckled and Vada X G.68 all from the collection of the Agriculture Experimental Station. Originally the trial included a fifth cultivar, Acadian from Trinidad. Its germination being very poor this cultivar was skipped. Some results are presented in Table 7.

Table 7 - Seed yields (kg/ha; 12% moisture) and 1000-grain weights (g) for four soyabean cultivars

cultivar	seed yield	1000-grain weight
	±200	±2
Laris	1826	90
H.L.S. 154	1197	104
Light Speckled	1492	87
Vada X G. 68	1523	101

Weather conditions considering yields were not bad. However, seed quality was rather poor. Laris, a black-seeded local variety, produced best, though statistically its yield only differed from that of H.L.S. 154. Under the conditions of the trial Laris did not prove better than Light Speckled and Vada X G. 68. Nor were these two cultivars better than H.L.S. 154.

JFW

4.3. HERBICIDES

The herbicides Igran 80, Gesatop 80, Gesaprim 80, Gesaprim S 80 and Semeron, all triazines, and Dicuran 80, a substituted urea, were tested as pre-emergents in a simple, non-replicated experiment with maize on sandy loam (72/6). The chemicals were applied immediately upon sowing at rates as recommended by the manufacturer.

Maize growth was very poor, probably as a result of water-logging, but no toxicity symptoms were observed. At the rates used the herbicides did not control the grasses, the most serious weeds on this type of soils. Control of dicotyledonous weeds was short-

lived; a crop of cowpeas immediately grown after the maize was not affected and produced relatively good yields.

TS

During the long rainy season a herbicide trial (72/10) was run at CELOS to study the effect of three chemicals on both crops and weeds. The crops included cowpeas, chinese cabbage and okra, which were grown on ridges to avoid water-logging. The herbicides tested were formulations of dalapon (Basfapon 85), chlorthal-methyl (Dacthal 75) and desmetryne (Semeron 25). Basfapon was tested on cowpea and okra, Dacthal and Semeron on cowpea and chinese cabbage. The effect of the herbicides was studied with and without additional hand weeding.

The chinese cabbage planting failed completely and will not therefore be considered. The effects of the various treatments on yield are presented in Table 8.

Table 8 - The effects of herbicides and weeding on the yields of cowpea and okra. Yields expressed as a percentage of the non-weeded control (= 100)

	herbicide treatment				average
	desmetryne	dalapon	chlorthal-methyl	control	
cowpea					
weeded	62	223		182	155
not weeded	18	199		100	105
okra					
weeded		480	374	349	401
not weeded		266	122	100	163

Under the prevailing conditions no chemical gave adequate weed control and additional hand weeding proved essential and beneficial. Poorest control was obtained with desmetryne. Moreover, this herbicide caused a nearly complete defoliation of the cowpea, which explains the very low relative yields obtained. Also dalapon caused some damage in this crop but the plants completely recovered.

Both dalapon and chlorthal-methyl resulted in a considerable yield increase. Also weeding led to higher yields irrespective of the fact whether a herbicide had been used or not. However, the increase was more marked as the yield level was lower.

In a third trial (72/39), conducted during the short rainy season, four pre-emergence herbicides were screened for their effectiveness in controlling weeds as occurring at CELOS. The formulations used were Afalon (a.i. linuron), Preforan (a.i. fluoridifen), Maloran (a.i. chlorbromuron) and Lasso (a.i. 2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide). The chemicals were used at rates as recommended by the manufacturer. Five test crops were grown viz. maize, groundnuts, soyabeans, green gram and cowpea. Seedlings were examined for possible herbicide damage. Crops were not grown to maturity and no yield data were collected.

The soyabeans emerged very poorly so that no records were taken from this crop. The herbicides used had no effect on seedling emergence. Some slight seedling damage was noticed where Preforan had been used, the damage consisting of distorted cotyledons and some spots on the young leaves. It had no effect on further plant growth.

Best and longest lasting control was obtained with Preforan and Lasso which particularly affected grasses. Maloran and Afalon mainly controlled the dicotyledonous weeds but Afalon persisted less well than Maloran. At the rates used none of the herbicides controlled sedges though Preforan, claimed to affect *Cyperaceae*, brought about some leaf spots in these weeds.

JFW

4.4. RIDGES AS A MEANS OF GROWING CROPS ON HEAVY ILL-DRAINED SOILS DURING THE WET SEASON (72/11)

In the wet season crop growth on the heavy, ill-drained coastal soils of Surinam is often hampered by water-logging and excessive weed growth. Since cambered beds do not normally provide a solution for the drainage problem, a preliminary trial was carried out during the long rainy season comparing crop growth on 50 and 100-cm wide beds with that on flat soil. Lack of suitable equipment and continuous wet weather made it necessary to build the ridges by hand. Two test crops were grown, cowpea and okra. A third crop, chinese cabbage, failed owing to poor seed quality.

Ridging had a marked effect on emergence. Though no differences in soil moisture content were detected immediately after sowing, the percentage missing cowpea plants on the flat soil was over four times higher than on the ridges. No consistent difference was found between the two types of ridge. Emergence in okra was affected too but far less than for cowpea, the difference being a mere 33%.

Apart from a few yellow and smaller plants growth in cowpea was little affected. However, okra plants were largest on the narrow ridges. Yield differences between treatments were not consistent for all replications, soil heterogeneity probably playing a major role. As a result no differences in cowpea yields were found. Cowpea yields for the 50 and 100-cm ridges were 97 and 125% respectively of those on flat soil. For okra these figures were 350 and 230. Owing to a large variation these differences were not statistically significant.

Soil moisture content at harvesting was lower for the ridges than for the flat soil and lower for the narrow ridge than for the wider one.

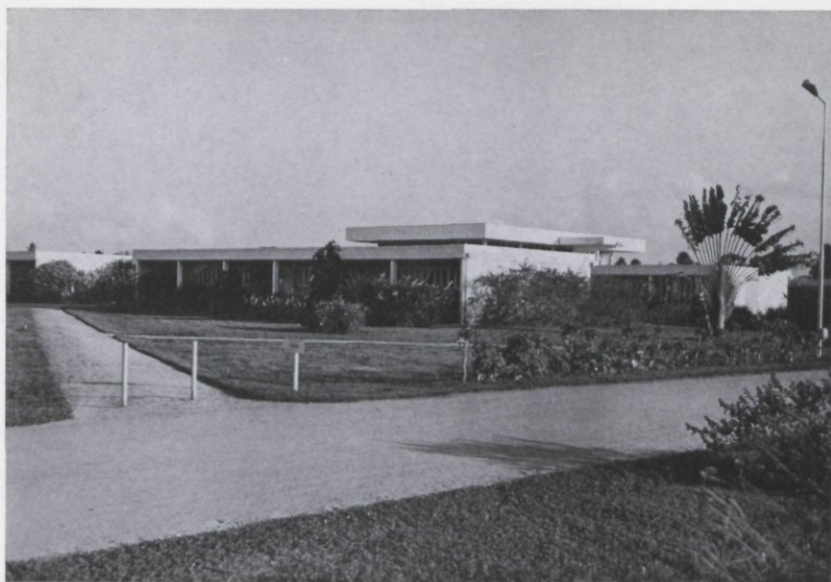
JFW

4.5. A CASSAVA YIELD TRIAL COMPARING DIFFERENT HARVESTING DATES (72/16)

Four cassava clones, Bitter IV and Bitter V of local origin and 2062 and 2195 introduced from Venezuela, which ranked amongst the best producers in a former experiment (71/4), entered a yield trial on the sandy soils of the Coesewijne formation. The trial consists of four complete blocks, two of which are laid down on unbleached sand and two on sandy loam. Plots comprise seven rows of four plants each, spaced 1 x 1 m. Three rows will be harvested 12 months after planting, leaving four rows of which one serves as a guard for the three to be harvested three months later.

No tillage took place. Gramoxone was used to kill the tropical kudzu cover present and the planting hills were slightly rooted. Fertilizer was applied immediately upon planting and half a year later, and consisted of 40 g NKP (15+15+15) per plant supplemented with 5.5 g of sulphate of potash-magnesia.

The clones differed in habit and growth pattern. Bitter IV and 2062 are erect types with rather thick stems. Bitter V and 2195 have a bushy appearance and thin branches. Large differences in vegetative growth were observed between the soil types. On the



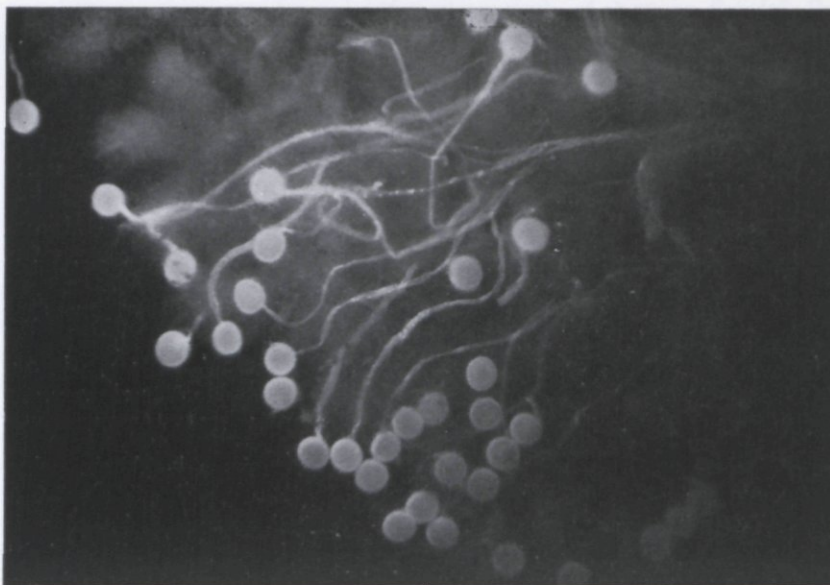
Partial front view of CELOS buildings.



Root excavation of Virola surinamensis. Note ground water.



Agathis stigmaterus parasitizing a larva of *Diatraea saccharalis*.



A fluorescence technique for incompatibility studies. Sweet potato pollen germinating on stigma of compatible cultivar.

sandy loam plants of all clones were distinctly sturdier and taller than on the sand, and showed less symptoms of water shortage (shedding leaves). At the end of the year an attack of leaf spot by *Cercospora cassiae* was recorded.

GAM

4.6. THE POSSIBILITIES OF SOME LEGUMINOUS CROPS ON THE SANDY SOILS OF SURINAM'S INTERIOR

During the year under review investigations were started to study the possibilities of growing groundnuts, soyabeans and green gram on the sandy soils immediately south of Surinam's coastal belt. To this end a number of observation plots were laid down and a few trials were run at an experimental site in the Cocbiti area.

Two different soil types could be distinguished, a very sandy soil and a loamy sand. Observation plots measuring 480 m² were laid down on each of these soil types. The soil pH being very low, half of each plot was limed. On the sandy soil ground limestone was applied at a rate of 3 tons/ha, on the loamy sand a rate of 4 tons/ha was used. All plots were fertilized with N, P and K, the rates varying with soil type and crop being grown. Half of the fertilizer was applied at sowing, the rest 3-4 weeks later. For each crop one to Surinam's coastal conditions adapted variety was used. *Rhizobium* inoculated seed was sown. Planting distances, chosen with a view to mechanical cultivation, were 60 x 15 cm.

Emergence was markedly affected by liming, it being highest on the limed plots. This particularly applied to green gram on the sandy soil where only a mere 3% was missing on the limed plots as against over 60% on the non-limed ones. A few weeks after emergence on many a spot in the soyabean plots on both soil types and in the plots on the sandy soil, plants stopped growing, turned yellow and then died. The symptoms closely resembled those of damping-off. They occurred less frequently on the heavier soil type than on the sandy soil; and less on the limed plots than on the non-limed ones. As a result the number of plants was strongly reduced. In spite of infilling immediately after emergence 75% of the green gram plants were missing on the non-limed sandy soil, as against 25% on the limed one. For the loamy sand these figures were 10 and 5 respectively. In the case of soyabean the percentages missing plants were 35 and 20 on the sandy soil and 25 and 10 on the loamy sand for non-limed and limed plots respectively. These symptoms were not noticed in groundnut, where apart from differences between soil types crop growth was very uniform.

Generally growth was better on the loamy sand than on the sandy soil. For soyabeans and green gram no closed crop was obtained. Groundnut provided a closed crop on the heavier soil only.

Insect damage was negligible. Mites and chrysomelids caused some leaf damage in soyabean. The two other crops were hardly affected. Weeds were virtually absent except for incidentally occurring spots on the loamy sands where mainly grasses appeared.

Final yields were rather low except for groundnut on the limed plots (Table 9). In most cases liming had a beneficial effect on crop yield, the low yields on the non-limed plots partly being explained by a reduced population. This particularly applied to green gram on the sandy soil. In groundnut liming had clearly affected the percentage w.w of non-filled pods. On non-limed sand and loamy sand these percentages were about 35 and 29 respectively whereas on the limed plots of both soil types combined a percentage of only over 10 was found.

Table 9 - Yields (kg/ha; 12% moisture) for groundnut (pods), soyabean and green gram (seeds) on sand and loamy sand with or without lime

soil type	groundnut	soyabean	green gram
sand + lime	*)	385	361
— lime	341	231	91
loamy sand + lime	*)	611	683
— lime	712	473	711

*) Groundnut yield combined for sand and loamy sand both plus lime : 1222 kg/ha.

As part of the aforementioned investigations a nitrogen trial (72/22) was carried out with soyabean and green gram on the sandy soil to study the effect on yield, nitrogen removal and nitrogen content of the seeds. Nitrogen was applied as urea at levels of 0, 20, 40 and 60 kg/ha. All plots received an over-all dressing of lime applied a few days before planting, and of P and K fertilizer half of which was applied at sowing, the remainder 3-4 weeks later. *Rhizobium* inoculated seed was used.

Yield levels (Table 10) in this trial were of the same magnitude as in the observation plots. Owing to a large variation within replicates no statistical differences were found between the various treatments.

Table 10 - Effect of nitrogen on seed yield (kg/ha; 12% moisture), N-removal (kg/ha) and N-content of the seeds for soyabean and green gram. Removal data determined at 57 and 83 days from sowing for green gram and soyabean respectively

	kg nitrogen/ha				S.E.
	0	20	40	60	
soyabean					
yield	362	383	280	266	57
N-removal	39.5	43.0	38.3	31.8	7.9
N-content seeds (%)	7.5	7.5	7.6	7.7	
green gram					
yield	333	353	381	544	71
N-removal	13.5	14.3	17.3	19.8	2.0
N-content seeds (%)	4.2	4.2	4.4	4.2	

The effect of *Rhizobium* inoculation was investigated with green gram in a separate trial (72/23) on the loamy sand. As in the observation plots and the nitrogen trial appropriate inoculum was used. The plots were limed and a basic fertilizer dressing was applied containing N, P and K.

Though plants from inoculated seed had more and larger nodules on their roots than those from non-treated seed, no statistical differences were found in seed yield, nitrogen removal and nitrogen content of the ripe seeds (Table 11).

Table 11 - Effect of *Rhizobium* on yield, N-removal at 60 days from sowing and N-content of the ripe seeds of green gram

planting material	seed yield (kg/ha)	N-removal (kg/ha)	%N ripe seeds
	±245	±8.5	±0.4
inoculated	959	37.0	4.1
non-inoculated	866	35.3	4.1

JFW

5. ENTOMOLOGY

5.1. THE RELATIONSHIP BETWEEN RICE BORERS AND THEIR PARASITES (68/1)

The sampling of lowland rice plots at CELOS as mentioned in the report for 1970, was continued in the year under review.

As in the previous year the percentage infestation by *Diatraea saccharalis* was nearly always below 1; also the same amount of parasitizing was found. For *Rupela albinella* percentages infestation were higher, reaching values of 3-16, but the borers were less parasitized than the year before. The high level of infestation previously reported remained until February.

For the first time in three years considerable numbers of diapause cocoons were found. For further details see section 5.2.

During 1972 three small-holders' lowland rice fields were sampled weekly. Only in one field the rice showed some, in the others virtually no infestation. Weekly samples were also taken from two fields in Western Surinam. In addition several plots were sampled just before harvesting. The percentage infestation varied considerably. It was less than at CELOS but higher than in the small-holders' plots.

Apart from *Metagonistylum minense*, a parasite of *D. saccharalis* found in Wageningen, Western Surinam, no new parasites were encountered. In this area, however, no *Strabotus* sp. was found.

PJH

5.2. THE BIOLOGY OF *Rupela albinella* (70/20)

The time required for the development of the different instars was determined by sampling artificially infested rice plants at 1 or 2-day intervals. The instars were classified according to the width of the headcapsules as mentioned in the previous annual report. The L₁ was found to be 11 days, the L₂ 5.6 days, the L₃ 8.8 days, the L₄ + L₅ 13 days and the pupal stage 12 days. Including the 7-8 days for the egg stage this amounts to an average time of development of ca. 58 days.

The stem cavity the larvae require for their development normally is available at about 60 days from sowing. The first moths emerged after about 105 days, a peak occurring from 125-145 days. As in 100 days old rice mortality of first instar larvae appeared to be very high, the variety used (Holland) — having a growth period of about 173 days — allows for only one generation. The borer cannot therefore complete its development in early maturing varieties.

For the first time in three years a considerable number of diapause cocoons were found. Though appearing from September till November this could not be explained by a dry period or by the age of the rice plants. However, the mean maximum and mean minimum temperatures were higher than in the other periods. Always more diapause cocoons were found in the screenhouse than in the fields, temperatures being higher there than outdoors. It probably is a matter of 1-2 degrees centigrade. In the field the diapause was broken after one month, i.e. before the crop was harvested.

PJH

5.3. THE BIOLOGY OF THE BORERS' PARASITES (70/32)

5.3.1. *Agathis stigmaterus* (CR.)

Parasites of *D. saccharalis* were reared as described in the previous annual report. Besides, 6-14 days old hosts were offered in stem pieces of about 3 cm in which a hole was made to force the larva through. One wasp was offered about ten of such pieces a time. After being parasitized the borers were either removed and placed on an artificial diet or dissected (after 5 days) to count the number of eggs deposited.

Parasitizing started at about 4 days after emergence. It ranged from 0-694 with an average of 130. After 5 days 71% of the hosts contained a parasite, i.e. 90 eggs per female. The total time required for the development from egg to adult was 31.5 days (range 23-90). The longevity was 11 days. Only 1-2% of the wasps reared were males.

5.3.2. PARASITES OF *R. albinella*

In Table 12 the biological data of *R. albinella* and its "larval" parasites are presented. As mentioned before the first moths emerge after about 105 days. Simultaneously the first *Venturia* sp. adults appear. *Strabotus* sp. and *Heterospilus* sp. are some days later. Maximum emergence occurs at about 135 days after sowing for *R. albinella* and *Venturia* sp. For *Strabotus* sp. and *Heterospilus* sp. it is about 10 days later. *Strabotus* and *Heterospilus* are able to complete about two generations in one rice cycle. They start on the first big larvae and take for the second generation the last big ones.

Table 12 - Biological data of *R. albinella* and its "larval" parasites

	<i>R. albinella</i>	<i>Venturia</i>	<i>Strabotus</i>	<i>Heterospilus</i>
stage of parasitizing	—	egg	L ₅ or pupa	L ₅
days to complete one generation	58	50-70	16-20	18-22
longevity of adult (days)	5	7-10	up to 60	15-20
number of ripened eggs in ovarium	?	up to 750	6-12	40-50
eggs produced	183	?	?	?
number of generations per rice cycle	1	1	1-3	1-2

PJH

6 FARM ECONOMICS

6.1. A FARM MANAGEMENT STUDY OF FRUIT AND VEGETABLE FARMS (71/13)

In order to obtain information on the underlying causes of the relative large price increases of fruit and vegetables, in 1971 a study was initiated on the production and marketing of these commodities. This study comprised: (i) a farm management study, (ii) a marketing study (see section 12.1) and (iii) a study of consumers' behaviour (see section 12.2).

Field work on the farm management study started in May 1971 with an inventory of 150 selected farms. (For further details of this study the reader is referred to the report for the year 1971.) Subsequently data were collected on labour, costs and yields. In August 1972 a final inventory concluded the field work.

From the original 150 farms only about 100 remained at the end of the study. The data collected were checked, sometimes amended, and eventually coded. Final processing and analysis will take place at the Department of Development Economics of the Agricultural University, Wageningen, The Netherlands.

CBH

7. FOREST ECOLOGY

The forest succession studies were continued in 1972; new plots were not staked out. The savannah-like part of the succession plot at Blakawatra on deforested land amidst pine plantations (67/1) (see former annual reports) is gradually becoming covered with bushes. The *Cecropia* spp. which form the uppermost canopy elsewhere in the plot are likely to decline in vitality during the next years. The storey of wooden plants underneath this canopy is developing well.

The succession plots at Sarwadiesprong (67/1) situated in deforested areas in a piece of virgin forest still show a substantial increment. In one of the plots the basal area of the secondary forest within six years reached a value comparable to that of the original virgin forest. The dominant species are *Cecropia sciadophylla* and *C. obtusa*.

The two 5-ha plots for studies on the regeneration of exploited forest (67/2) were recorded again this year. Exploitation here has been light by international standards, but rather heavy by Surinam ones. About 5-8 trees per ha were obtained. Some growth records are shown in Table 13.

Tabel 13 - Mean girth increment (mm/year) for the period 1968-1972, and numbers of recorded trees in the succession plots in worked-out forest at two locations

girth class (mm)	plot at Goliath		plot at Sarwaweg	
	girth increment	number of trees	girth increment	number of trees
100-157	2.4	81 ¹⁾	1.4	83 ¹⁾
157-471	4.9	178 ²⁾	3.5	185 ²⁾
471-785	7.7	163 ³⁾	6.3	180 ³⁾
> 785	10.8	651	9.5	661

1) applies to 5 sub-plots with a total area of 0.1 ha

2) ditto, total area 0.2 ha

3) ditto, total area 1.0 ha

Girth increment increased with increasing girth, which is explained by the fact that bigger trees receive more light. If only the upper girth class is considered, it appears that some valuable species such as basalocus (*Dicorynia guianensis*) and wana (*Ocotea rubra*) grow at above-average rates. Basal area in the plots is slowly increasing, but still differs notably from the original value.

The trials with seed from *Cecropia* spp. (70/21) were continued. In vitro storage tests demonstrated that under laboratory conditions the seeds remained viable for more than a year. A storage test in vivo (with seed of *C. sciadophylla*, as only seed of this species was at hand) was started in November. Seeds are mixed with forest soil and placed in small earthenware pots which are buried in the forest at 25 cm below groundlevel. Pots will be lifted at 6-month intervals and the seeds tested for viability according to some standard tests.

NRG

8. FORESTRY TECHNIQUES

At CELOS research in the field of forestry techniques is restricted to questions regarding the relationship between men and work under forestry conditions in the tropics. Frequently occurring forestry activities are analysed and described by work studies (see Work science), and the work load is measured (see Work physiology). As to the labourers, work capacity measurements (see Work physiology) and a medical screening are carried out. In addition the occurrence of absenteeism caused by illness is examined (see Occupational health).

Some assistance was given to work physiological research of the agricultural engineering department.

8.1. WORK SCIENCE

The research during 1972 mainly dealt with weeding by machete in young plantations of *Pinus caribaea*. It comprised time and work physiological studies. As to the former records were taken on the time spent on the different work elements, on the performance, the number of machete strokes per unit time, the different kinds of weed and the heights of the pine trees. In this way standard values were obtained in behalf of the work physiological research. For the work physiological aspects of these studies see below.

8.2. WORK PHYSIOLOGY

During the year under review the labourers' work loads in different types of field work and their work capacity were measured. The loads of their blood circulation and lung ventilation systems were measured during weeding operations carried out with a machete in young plantations of *Pinus caribaea*. In addition some assistance was provided in work physiological investigations of the agricultural engineering department which dealt with mowing grass with machete and scythe, and weeding with a scuffle hoe, a long handled hoe, a traditional hoe and a cultivator. Pulse rate and energy consumption were recorded during these field activities. The pulse rate was measured by an electro-cardio-tachometer and transmitted telemetrically to a monitor connected to a pen-recorder (single channel Hellige telemeter). Energy consumption was calculated by measuring the ventilation and oxygen consumption. Ventilation was measured with a Mueller-Franz respirometer whereas the oxygen consumption was determined either chemically, according to Haldane, or paramagnetically, with a Servomex 101. The work capacity was established with a submaximal test on a bicycle ergometer. The maximal aerobic power was estimated from the relation pulse rate and work load according to Astrand.

8.3. OCCUPATIONAL HEALTH

A group of creole forest labourers was used to investigate the causes of absenteeism, especially those related to illness. In co-operation with the Institute for Medical Science (I.M.S.) in Paramaribo a selection of the same group was medically screened.

During the first quarter of 1972 absenteeism caused by illness turned out to be 2.4% on a total of 91 days, depending on the tenure. When tested by the I.M.S. these labourers were found in good physical condition. Remarkable were several cases of eosinophily, various cases of anaemia, among which a few very serious ones, and the frequent occurrence of — sometimes extreme — hypertension.

FJS

9. HORTICULTURAL AND AGRICULTURAL HAND-TOOLS

9.1. SCYTHE AND BUSH-KNIFE, A COMPARISON OF PERFORMANCE AND WORK LOAD (71/10)

Output, physical work load of the labourer and quality of the work were compared for three scythe types and a bush-knife. The work, which was carried out by an adult, comprised mowing an old and medium-old grass vegetation. A description of the tools is given in Table 14.

Table 14 - Measurements (cm) and weights (kg) of the various tools

tool	length of cutting blade	length of shaft*) or handle	weight
bush-knife	54	15	1.05
scythe 40	40	140	2.05
scythe 60	60	140	2.35
scythe 80	80	140	2.65

*) two handles were mounted on the S-shaped iron scythe-shafts, one at its top and one at 45 cm from the top.

The pulse rate was recorded before, during and after the work. The work pulse, which is defined as the difference in pulse rate between work and rest, was used as a measure for the physical work load. This load did not differ much for the various tools except for the scythe 80 when used in old grass (Table 15), which suggests that for mowing old grass this scythe was less suitable than the other tools.

Table 15 - Work pulse, pulse rate at rest, net working time and work pulse per unit area

tool	work pulse (beats/min)	pulse rate at rest	net working time (min/m ²)	work pulse (beats/m ²)
medium-old grass				
bush-knife	47	83	0.24	11.09
scythe 40	42	84	0.20	8.32
scythe 60	50	80	0.15	7.35
scythe 80	46	80	0.14	6.26
old grass				
bush-knife	44	88	0.35	15.44
scythe 40	44	83	0.21	9.15
scythe 60	44	82	0.20	9.60
scythe 80	60	81	0.15	8.76

Net working time was highest for the bush-knife. Apart from this tool the working time was only little affected by the age of the grass. For the bush-knife the work pulse per unit area was about 1.5 times that for the scythes.

The mowing rate with the bush-knife (Table 16) was somewhat higher than that with the scythes; for the latter it decreased with increasing blade length. The area mown

per stroke increased with the length of the cutting blade. The swad widths for the various scythes were about the same in each vegetation; they were about 20-30 cm wider than for the bush-knife. As for the quality of the work the stubble length was about the same irrespective the tools used.

Table 16 - Mowing rate, number of strokes per unit area and swad width

tool	number of strokes		swad width (m)
	per min	per m ²	
medium-old grass			
bush-knife	36.7	8.40	1.30
scythe 40	31.3	6.23	1.65
scythe 60	30.2	4.34	1.65
scythe 80	28.1	3.79	1.70
old grass			
bush-knife	34.7	12.00	1.30
scythe 40	32.9	6.85	1.50
scythe 60	30.6	6.02	1.50
scythe 80	26.5	3.83	1.52

Upon completion of the experiment the labourer's working capacity was determined for which both the step test and the bicycle ergometer were used. At same time the relation between the pulse rate and the energy consumption was determined by measuring the ventilation and the oxygen consumption. It appeared that the labourer was in a good physical condition.

TS

9.2. WEEDING TOOLS

In the long dry season a comparison was made of weeding tools in a crop of maize and a crop of soyabeans on a heavy sandy clay (71/10; 71/26). The row distance of the maize was 90 cm and that of the soyabeans 45 cm. The tools used were a traditional hoe, a long handled hoe, a scuffle hoe and a cultivator. For their measurements and weights the reader is referred to CELOS Bulletins, 16, p. 23.

The tools were compared for net working time per unit area, physical work load of the labourer and weeding effect. The study was performed with two adult labourers. Soil conditions to carry out the various operations were generally good. The experimental plot was divided in two sub-plots; in one only the pulse rate was recorded whereas in the other also the ventilation was measured. Energy consumption was computed from the ventilation and the oxygen consumption, the later being determined on samples of expired air. From the results (Table 17) it appeared that in the second sub-plot the pulse rate was consistently higher than in the first one. Since the net working time was only slightly lower measuring the ventilation must have had an adverse effect on the load of the circulation.

Table 17 - Net working time, pulse rate and energy consumption

tool	net working time (min/m ²)		pulse rate			energy consumption**)	
	I*)	II*)	rest	I	II	per unit time (Kcal/min)	per unit area (Kcal/m ²)
traditional hoe	0.558	0.537	84	118	130	4.10	2.20
long handled hoe	0.488	0.503	84	113	122	3.52	1.77
scuffle hoe	0.577	0.502	88	123	134	3.87	1.92
cultivator	0.568	0.521	84	125	138	4.61	2.24

*) First and second sub-plot.

**) Second sub-plot only.

There were considerable differences in energy consumption per unit area between the various tools. However, in spite of the many observations made these differences were not statistically significant owing to a large variation in the experimental data. This variation can be explained by the difficulty encountered in controlling the working rate, which amongst other things was affected by differences in soil structure.

The weeding effect of the different tools was determined by estimating the percentage area covered by weeds both before and about one week after weeding. On the whole weeding reduced this area to about one tenth of that before weeding (Table 18). Further work is required to translate the differences in quality of weed control into terms of competition between crop and weeds.

Table 18 - Quality of weed control expressed as the percentage area covered by weeds

crop	before weeding	ca. one week after weeding			
		traditional hoe	long handled hoe	scuffle hoe	cultivator
maize	58.4	2.1	4.3	6.4	7.3
soyabeans	31.8	2.9	3.2	3.6	4.5

TS

10. HYDROLOGY

10.1. THE DETERMINATION OF EVAPOTRANSPIRATION WITH A WEIGHABLE LYSIMETER (70/23)

During the year under review the construction of the lysimeter, which started in 1971 (CELOS Bulletins, 16, p. 25), was completed. After testing the weighing system the manometer was calibrated and the measuring fault calculated. The standard deviation of a single measurement was found to be 0.5 mm, which indicates that the lysimeter is not suitable for measuring evapotranspiration over very short intervals like a few hours. Accuracy is increased if longer intervals are used.

10.2. THE EVAPOTRANSPIRATION OF TOCGRASS (*Ischaemum aristatum* L.) - A COMPARISON OF METHODS (70/23)

During a four-month period (72.08.21 - 72.12.20) the potential evapotranspiration of tocgrass as measured with the lysimeter was compared with the Class-A-Pan evaporation and the evaporation as being computed with the Penman formula.

To ensure a continuous water supply in the rootzone the lysimeter was sprinkled at a tensiometer reading of 20 centibars. Measuring started when the grass had completely covered the lysimeter area. To keep the grass continuously in the same vegetative stage it was cut three times a week during the course of the experiment.

The Class-A-Pan was situated on the meteorological field some 50 m away from the lysimeter.

Except for wind velocity all data required for the computation of the Penman evaporation were obtained from own meteorological observations.

Evapotranspiration was measured over 10-day intervals. The mean values over the period of observation are presented in Table 19.

Table 19 - The potential evapotranspiration of tocgrass as measured with a lysimeter (ET) compared with the evaporation from a Class-A-Pan (E_p) and the Penman evaporation (E_0)

ET	42.2 mm	ET/ E_p	0.98
E_p	43.4 mm	ET/ E_0	0.79
E_0	53.6 mm	E_p/E_0	0.81

WHV

10.3. THE RELATION BETWEEN INCOMING SHORT-WAVE RADIATION AND RELATIVE SUNSHINE DURATION (72/5)

To be able to compute the evaporation with the Penman method it is necessary to know the amount of solar radiation reaching the earth's surface.

The incoming radiation mainly consists of short-wave radiation (R_c) and may be deduced from the relation $R_c = R_a (a + b \frac{n}{N})$, in which R_a is the amount of short-wave radiation at the top of the atmosphere, and $\frac{n}{N}$ the relative sunshine duration. a and b are empirical constants which may vary from place to place, depending on atmospheric conditions. The amount of short-wave radiation was measured during three different periods with a Kipp solarimeter.

The first two periods coincided with the rainy season the third one with the dry season. The R_a values were obtained from the Smithsonian Meteorological Tables. From the results obtained (Table 20) it may be concluded that with a completely covered sky a higher percentage of the incoming short-wave radiation reaches the earth's surface during the dry season than during the rainy one whereas on cloudless days the opposite occurs.

Table 20 - The constants a and b as calculated during three different periods

period		empirical constants	
no.	duration	a	b
1	72.06.09 - 72.07.23	0.31	0.45
2	72.09.01 - 72.10.01	0.30	0.45
3	72.10.01 - 72.11.01	0.33	0.39

WHV

11. IRRIGATION

11.1. AGRONOMICAL AND ECONOMICAL ASPECTS OF SUPPLEMENTARY IRRIGATION IN CITRUS (72/73)

To study the effect of supplementary irrigation on flowering, fruit setting, fruit growth and vegetative development in citrus, an irrigation experiment will be conducted over 16 ha of a 5 years old citrus plantation on high terrace soils. The experiment is to start at the beginning of 1973. Prior to this experiment, which because of expected cumulative effects will last for at least 4 years, a preliminary trial was set up (i) to collect as much practical information as possible on suitable measuring techniques and, (ii) to come to an optimal lay-out of the main experiment. This preliminary trial started in October of the year under review and will last until March 1973.

WHV

12. MARKETING AND MARKET RESEARCH

12.1. A MARKETING STUDY OF VEGETABLES (71/24)

As part of an overall study of the production and marketing of fruit and vegetables in Paramaribo and its surroundings (see section 6), an investigation of the marketing structure was initiated in October 1971, to obtain information on:

- (i) the sales and profits of the different types of wholesaler (commission-agent, middleman etc.);
- (ii) the sales and profits of the retailers at the capital's Central Market;
- (iii) the farmer's position in selling his products; and
- (iv) the extent to which Government is involved in the present structure.

For one month observations were made of and talks held with the directly involved persons at the Central Market during wholesale hours (23.00-08.00 h). The data thus obtained were checked and processed.

A survey was made of all existing types of traders. Because of the different patterns of wholesaling it is impossible to arrive at a general wholesale profit percentage, particularly since some traders represent a combination of sorts. Profits also depend strongly on the type of commodity. Nevertheless some (rough) profit calculations were made per type of vegetable. At the same time during a 2-month period some 60 retailers out of a 500 were interviewed about price, volume, time and source of buying. Where possible the quality of the products was noted. From these data and from consumer prices collected by the Ministries of Agriculture and Economic Affairs, profit margins were calculated. They appeared to range from about 75 up to sometimes 400% depending on the type of vegetable. A 100% profit margin seemed to be a general average. It was also found that about half the number of retailers buy directly from the farmer whereas the other 50% buy from wholesalers. From the data collected at both retailers and wholesalers level, the value at wholesale prices of the marketed vegetables was estimated at about Sf. 15,000 on a normal day and at twice that amount on Saturdays and days before holidays.

As to the farmer's position in selling his products conclusions cannot be drawn until the farm management study has been completed.

To ascertain to what extent Government is involved in the marketing structure, public as well as private reports and notes were studied and discussions held with officials of the Ministries concerned. Many good reports on the subject of improvement of the marketing of vegetables appeared to exist in the files of the Ministries of Economic Affairs and Agriculture in particular. From these reports and from the discussions it appeared that the difficulties that exist are those which arise if two or more official bodies deal with the same matter without proper co-ordination.

CBH

12.2. AN INVESTIGATION OF THE CONSUMPTION OF FRUIT AND VEGETABLES IN PARAMARIBO AND ITS SURROUNDINGS (71/27)

Since an analysis of the problems that beset the marketing of fruit and vegetables is not complete without taking into account the consumer, an investigation was started into the consumer's behaviour in relation to these commodities.

Only supplementary information needed to be gathered. During 1968/69 a fairly thorough budget study was undertaken, the data of which provided most useful infor-

mation on the subject. The supplementary study originally embraced two classes, viz. the high-income group and the families the head of which was unemployed. The sample for the latter group was obtained through the employment bureau, whereas, because of lack of alternative data such as income tax, the sample for the high-income group was obtained from the telephone directory. As in the "unemployed" group nearly all heads of family nevertheless appeared to have a job, the investigation in this class was stopped after two months. This lowered the coverage from about 96 to 90% of the population involved.

During a 12-month period starting December 1971, each month some 24 families were interviewed daily. If they so wished the interviewees could write down the information themselves, the forms being collected twice a week. Questions were about prices paid, quantities bought and the buying places. During the final interview the consumer was asked about his income and the size of his family.

Processing and analysis of the data obtained are taking place at the Department of Development Economics of the Agricultural University, Wageningen, The Netherlands.

CBH

13. PLANT BREEDING

13.1. FRUIT SETTING IN SWEET POTATO, *Ipomoea batatas* (L.) LAM. (69/17)

The investigations to determine the relative importance of incompatibility and sterility mechanisms in reducing fruit setting and seed formation in sweet potato forged ahead in the year under review.

13.1.2. POLLINATION PROGRAMME

No further introductions entered the incompatibility programme. Special attention was paid to the poorly flowering clones and to the recent introductions. They were planted in large numbers both on ridges and trellised along chicken wire and on flat beds without any support.

Some 13,000 pollinations were made, about 7000 of them being intervarietal combinations. The remaining 6000 were selfings of F_1 plants or backcrosses to the parents. As in foregoing years fruit setting percentages and average numbers of seeds per capsule were very low.

In Table 21 some data are presented on fruit setting and seeds per fruit. Fruit setting percentages were low for most combinations of both intervarietal crosses and F_1 selfings and backcrosses. Figures of over 30% were found in only about 5% of the cases. The similarity between groups for numbers of seeds per fruit is striking. These findings stress the important part played by sterility factors as already stated in the report for the year 1971.

13.1.3. RELATIONS BETWEEN STYLE AND POLLEN

Pollen germination studies with the aid of the fluorescence technique were continued. A total of 441 intervarietal combinations (including 26 selfings) had been studied at the end of the year. From Table 22 it can be seen that there was no complete conformity between the microscopical observations and the results obtained in the field (fruit setting). Particularly surprising is the large number of combinations that show no pollen germination but still result in fruit setting. Special attention will be given to the combinations involved.

13.1.4. POLLEN VIABILITY IN VIVO

Pollen from ten cultivars was stained with solutions of four tetrazolium salts, viz. 2,3,5-triphenyl tetrazoliumchloride (TTC), 2-(p-iodophenyl)-3-(p-nitrophenyl)-5-phenyl tetrazoliumchloride (INT) and 3-(4,5-diamethylthiazolyl-2)-2,5-diphenyl tetrazolium-bromide (MTT). Pollen was collected at 7.00, 10.00 and 13.00 h. Counting the stained and unstained pollen grains started 30 minutes upon treatment. As a control pollen was also treated with acetocarmine and lactophenol cotton blue. For all cultivars it was found that the percentages stainable pollen were about twice as high with INT and MTT than with TTC and TR. In some clones the percentage decreased rapidly between 10.00 and 13.00 h. but mostly the decline was not so pronounced. A large variation in stainability between clones was observed.

Table 21 - Fruit and seed setting data for sweet potato as obtained in the period August 1969 to December 1972 inclusive

group	combinations made	percentage fruit setting				% successful combinations	number obtained		
		0	0.1-10.0	10.1-20.0	20.1-30.0		capsules	seeds	seeds/fruit
intervarietal crosses	412	146	154	63	25	24	65	1071	1401
F ₁ selfed	290	118	124	30	7	11	59	513	691
backcrosses	227	81	98	32	12	4	64	652	862

Table 22 - Relation between fruit setting in the field and microscopical observations.

+ = pollen tubes in style; (+) = occasional pollen tubes in style
 ± = pollen germination on stigma; (—) = occasional germination on stigma
 — = no germination
 o = fruit setting; x = no fruit setting

microscope	field			total	% conformity
	o	x	not re- corded		
+	181	50	69	300	78
(+)	5	7	11	23	—
±	8	8	6	22	—
(—)	10	8	9	27	—
—	24	34	11	69	59
total	228	107	106	441	—

13.1.5. SEED EMERGENCE

About 700 seeds, harvested between October 1971 and October 1972, were sown after a 10-minute treatment with concentrated sulphuric acid. As in foregoing years a clear relation between seed weight and emergence was found (Table 23).

As may be seen from Table 24 the distribution of seed weight depended on the female parent.

Table 23 - Relation between seed weight and emergence in sweet potato. For comparison the results of 1970 and 1971 have been included

seed weight (mg)	total sown	emerged	not emerged			
			1972		1971	1970
			number	%	%	%
< 10	108	—	108	100	97	100
11-13	90	14	76	84	56	86
14-16	125	59	66	53	37	50
17-19	166	120	46	28	27	24
20-22	144	116	28	19	4	8
23-25	59	51	8	14	20*	17
26-28	7	6	1	14	0*	0*
total	699	366	333			

* very small numbers

Table 24 - Relation between female parent and seed weight

female parent	seed weight (mg)						
	10	11-13	14-16	17-19	20-22	23-25	26-28
Blauwkop	18	10	7	1	—	—	—
Sunny Side	—	6	14	15	1	—	—
A 138	29	32	34	53	17	—	—
White Star	1	1	6	10	23	7	1
Louisiana 2	16	11	8	12	35	21	—

GAM

13.2. RECURRENT SELECTION IN MAIZE, *Zea mays* L. (72/9)

A heterogenous mixture of local maize served as the starting material for a maize selection programme initiated in 1968. After two generations of negative mass selection against strikingly off-type plants, especially for ear and seed characteristics, 40 superior ears were chosen in 1969. Their progenies were evaluated in two successive seasons for general performance, flowering, ear characteristics and yield. As many plants as possible were selfed. Out of a total of 4000 plants 111 I_1 lines were selected. The bulked grain of these lines was sown in 1970 on a 700-m² plot. Part of the progeny resulting from open pollination was saved for further selection. As the yield equaled 4900 kg/ha the remainder was released as selection 68054CSI. This selection was planted at several locations all over the country by small-holders and the extension service with good result.

A 2000 m² plot of 68054CSI was planted in the short dry season of 1972. Closing of the husks and the angle between main stalk and ear were added to the abovementioned selection criteria. Selfing was impossible because of wet weather conditions during silking. Instead 1200 well-performing open-pollinated plants were preselected. Evaluation of the ear and kernel characteristics led to a final selection of about 200 superior plants.

Part of the bulked selection (68054CS2) was saved, the remainder being sown early September 1972 on five cambered 6-m wide beds for further selection. For unknown reasons performance was rather poor. Waterlogging in the early growth stages may have played a role. Bagging and selfing of relatively good plants was restricted to a ten-day period immediately upon flowering, i.e. from 60-70 days after sowing. As the number of selfed plants was rather small, some open-pollinated ones were included in the preselection. Preselected plants were harvested individually. Final selection was based on ear and kernel characteristics, including ear number, ear length, mid-ear circumference, grain insertion, and shape, colour and weight of the kernels. The final choice contained 234 selfed and 162 open-pollinated plants, out of totals of 1170 and 270 plants respectively. The grain has been bulked and the selection - named 68054CS3 - will be evaluated in comparative yield trials.

Superior ears of open-pollinated plants in a block comprising 104 Caribbean composites grown in 1971 were put together and named "Caribbean blend". This mixture

was sown on a number of beds prepared under extremely unfavourable conditions, mid-September 1972. Emergence was irregular and, locally, very incomplete, but no infilling took place. Early growth was hampered by waterlogging followed by soil capping. Milling and natural drying-up of the beds, however, greatly stimulated plant growth so that many plants ultimately reached heights of over 300 cm. General performance was good and, despite an extended flowering period, nearly all plants bore one or more well-filled ears. Harvesting took place 122 days after sowing. The yield amounted to about 3900 kg/ha. It was concluded that the "Caribbean blend" may be a valuable source for recurrent selection.

A grain mixture collected in Suriname's interior near the bush negro settlement "Njoenjacobkondre" was sown on a 1200 m² large area in the experimental garden "Coebiti" on sandy loam. The soil was not tilled. The cover of tropical kudzu was killed by cutting followed by two Gramoxone applications, eight and one day before sowing. Emergence was about 80%. Performance was variable; compared to that on clay soils in the coastal belt it ranged from rather good to poor.

On spots with a poor stand plants were not larger than about 150 cm, showing early yellowing and withering of the lower leaves and forming very small ears if any. Elsewhere plants were about 200-250 cm. They did not suffer heavily from drought and remained darkish green until maturing. Well-performing plants of each row were bagged and selfed. They were harvested separately and their grain bulked together with some 40 kg from open-pollinated plants of good appearance. This mixture will be used for further selection. Total yield, including the poor plants, was at a rate of 1600 kg/ha. This low figure, apart from soil conditions and resulting growth variation, is explained by the showery weather upon bagging so that much of the pollen collected in the bags for selfing of superior plants was destroyed.

GAM

13.3. BREEDING SYNTHETIC VARIETIES IN MAIZE, *Zea mays* L. (69/24)

In 1972 the first synthetic variety based on local inbred lines was released. It was tested for general appearance, earliness, and production capacity, at two locations, i.e. the Centre's grounds where heavy clay soils predominate and on a sandy loam soil of the Coesewijne formation. An area of ca. 1200 m² divided over five adjacent 6-m beds of various lengths, was used on clay soil. Spacing was 90 x 30 cm. The plants performed very well and were quite uniform as to growth rate, stalk height and flowering time. Tasseling started 60 days after sowing. Some data are summarized in Table 25.

Table 25 - Average values of some characteristics of the synthetic maize variety

bed	stalk height (m)	flag leaf height	number of well- filled ears	number of incompletely filled ears
1	2.42	2.02	1.06	1.12
2	2.38	1.98	1.05	1.22
3	2.34	1.93	1.02	1.05
4	2.35	1.97	1.03	0.99
5	2.24	1.94	1.09	1.00

The crop matured between 115 and 120 days from sowing. Grain production varied from 4015 to 4090 kg/ha, with an average of 4070 kg/ha. The average 1000-grain weight amounted to 282 g. Kernels are of the dent type, orange or reddish coloured, with flattened sides.

A 1600-m² area was planted on the sandy loam. Differences in soil conditions caused large variations in performance. Despite high doses of fertilizer (5500 kg CaCO₃, 120 kg N; 90 kg P₂O₅ and 120 kg KCl per ha) grain production was only 1940 kg/ha. Water shortage and a low cation exchange capacity probably are the main causes of the disappointing yield on this soil type.

Out of 82 inbred lines (I₇) of Central-American origin 41 (sub)lines were selected and sown in alternate rows with the local selection 68054CSI for top-crossing. The lines were evaluated for general performance, plant height, stem circumference, ear number, ear- and kernel characteristics and uniformity. After final selection 16 lines were chosen for a top-cross progeny test. Two excelled in ear- and kernel characteristics, they will be partly saved for future hybrid breeding.

In 1971 some hundreds of well-performing plants out of 104 Caribbean composites had been selfed. I₁ lines of the best 44 plants were sown in a top-cross block in alternate rows with 68054CSI. The lines were evaluated in a similar way as the Central-American inbreds except for uniformity. Only the very variable lines were discarded beforehand. Selection yielded seven excellent and nine good lines. Their top-crosses will be compared in a progeny test trial.

GAM

14. PROTEIN IN FOOD CROPS

For a general introduction to this multidisciplinary research project the reader is referred to the report for 1969.

As yet no conclusion could be drawn from an experiment conducted in 1969 and 1970 that was concerned with the question whether the protein content and protein nutritive value of sweet potato tubers are affected by variations in growing seasons, fertilizing and age at harvesting (70/1).

Most other experiments started in 1969 and 1970 were closed in the year under review. An account is presented below. Moreover, additional samples were collected and sent abroad for chemical analyses, as part of the investigations dealing with the relation between protein content and quality on the one hand and type of variety on the other (70/31).

14.1. PROTEIN CONTENT AND COMPOSITION OF SWEET POTATO TUBERS AND GRAINS OF COWPEA, SORGHUM AND MAIZE AS AFFECTED BY THE DRYING TEMPERATURE (69/34)

As long as all chemical analyses connected with the protein project had to be carried out in the laboratories of the Department of Nutrition of the Agricultural University at Wageningen, the products harvested in the experiment had to be airfreighted to the Netherlands in the form of dry powder. Consequently it was necessary to investigate whether drying of such products as tubers of sweet potato and grains of cowpea, sorghum and maize at relatively low temperatures causes decomposition of proteins.

Recently harvested samples of these products were dried at either 45, 65 or 85 degrees centigrade and subsequently ground, shipped to Wageningen and analysed. Though the differences in crude and real protein content between the samples dried at these three temperatures were small, the results suggested that in several cases decomposition of proteins had occurred. Particularly sweet potato appears to be affected by the higher temperatures.

JR

14.2. PROTEIN CONTENT AND COMPOSITION OF FOOD CROPS AS AFFECTED BY PLANT DENSITY (70/30)

In the reports for 1970, p. 11-13, and 1971, p. 9, an account was given of spacing experiments with sorghum (70/17), cowpea (70/18) and green gram (70/19). The spacings used were 20 x 20, 30 x 30 and 40 x 40 cm.

Samples were taken from the dry grain to trace a possible relationship between the density of the plants and the protein content and composition of their seed. A summary of the results is presented in Table 26. As appears from the figures, density had a considerable influence upon yield but did not affect protein content. Other data, not published here, show that also protein composition was unaffected.

Table 26 - Yield and protein contents of sorghum, cowpea and green gram grown at various spacings

crop and spacing	yield (tons/ha)	protein content of the seed (% of dry matter)	
		crude protein	real protein
sorghum cv. Martin			
20 x 20 cm	2.98	9.8	9.3
30 x 30 cm	2.26	10.0	9.5
40 x 40 cm	1.40	9.4	9.0
cowpea cv. African Red			
20 x 20 cm	0.99	24.1	20.8
30 x 30 cm	1.22	23.1	20.9
40 x 40 cm	0.77	22.5	20.3
green gram cv. 68002			
20 x 20 cm	1.03	23.6	21.9
30 x 30 cm	0.98	24.6	22.9
40 x 40 cm	0.73	23.7	21.7
green gram cv. 68007			
20 x 20 cm	0.98	25.8	24.2
30 x 30 cm	0.69	26.0	24.1
40 x 40 cm	0.77	25.9	24.0

JR

14.3. PROTEIN CONTENT AND COMPOSITION IN CULTIVARS OF FOOD CROPS (70/31)

14.3.1. SWEET POTATO

An experiment carried out in 1970/71, and described in the report for 1971, p. 13-14, brought to light considerable differences in the yielding capacity of 12 sweet potato clones. Furthermore nearly all clones proved more productive at 4½ than at 6½ months after planting (in the previous annual report it was erroneously stated that the second harvest took place at 5½ months from planting). It was suggested that the latter phenomenon may have been caused by the very wet conditions between both harvests, bringing about decay of the tubers.

In order to trace differences between the clones as to their protein content and composition, tuber samples were taken from all of them at the first as well as the second harvest. At 4½ months after planting the content of real protein varied from 4.4 to 7.8% of dry matter. At 6½ months from planting, however, it was on an average 1.7% lower, apparently as a result of the rot which attacked the tubers during the last two months. Differences in protein composition between clones as well as harvests were not observed.

JR

14.3.2. SORGHUM

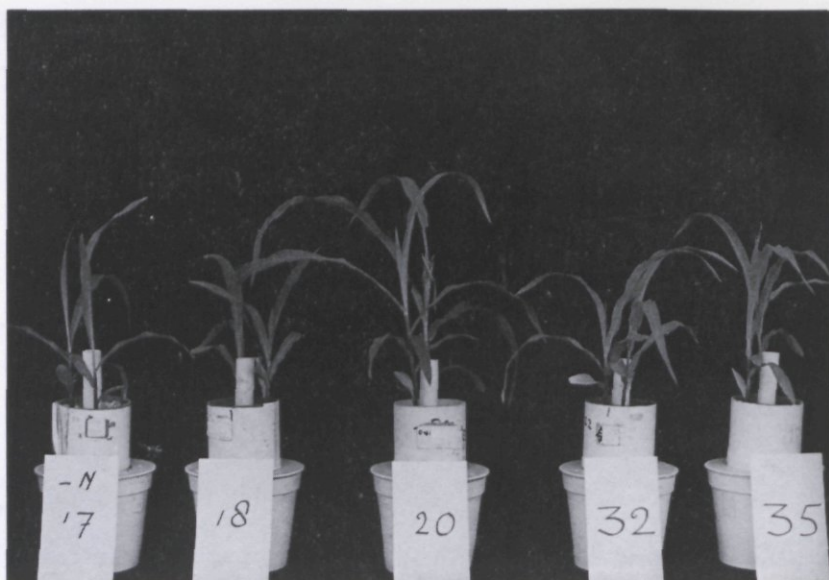
In 1971 ten open-pollinated cultivars of *Sorghum bicolor* (cvs. ARK 3001R, SB 65, SB 68, SB 79, Dobbs 28, Dochna, Solor Koenig, 160-Cernum, "Baboenhol" and Martin)



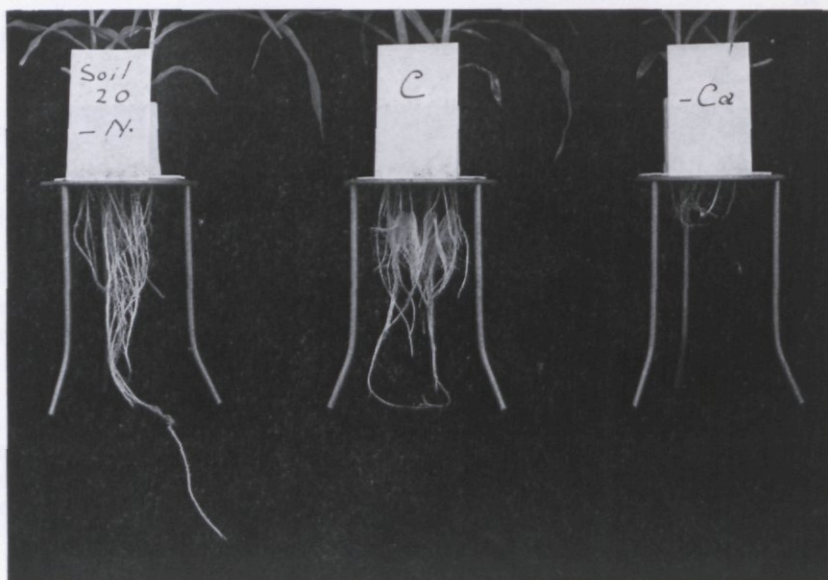
Plant height measuring in Caribbean maize composite from CIMMYT.



Measuring energy and oxygen consumption during the felling of heavy trees in tropical rain forest.



Seventeen days old maize plants on different soils (upper pot) and on a solution without nitrogen (lower pot). From left to right: clay loam, sand, clay, Dutch and Turkish soil, with sufficiency quotients for nitrogen (SQN) of 0.53, 0.45, 0.73, 0.48 and 0.53 respectively. See p. 52.



Root development of 17 days old maize plants in different nutrient solutions: minus N, complete and minus Ca. Soil: clay. See p. 52.

were grown in a simple experiment replicated twice. Plots consisted of six rows of 17 plants, spaced 90 x 30 cm. Emergence was between 80 and 100% except for one of the replications of ARK 3001R (19%), 160-Cernum (46%) and "Baboenhol" (34%). Nevertheless yields were very low. Excluding plots with a low plant density yields ranged from 1650 to 7150 g per plot or 600-2600 kg/ha. The yields of the lowest producing six varieties among which Martin averaged less than 1000 kg/ha. Solor Koenig and SB 65 produced 1050 and 1530 kg/ha respectively, only Dobbs 28 and SB 79 yielding over 2 tons/ha. The low yields of several cultivars may partly have been caused by severe attacks of fungus diseases such as *Cercospora sorghi* and *Helminthosporium (turcicum?)*. SB 65, SB 68 and Dochna appeared very susceptible; little symptoms were found in ARK 3001R, Dobbs 28, 160-Cernum and Martin.

Protein content varied from 8.37 (SB 68) to 15.65% (Solor Koenig). However, large differences between replicates were sometimes found, especially for Solor Koenig (10.24 vs. 15.65%), 160-Cernum (13.03 vs. 10.24%) and SB 68 (8.37 vs. 10.87%). Further chemical analysis for lysine and methionine content is still in progress.

GAM

14.3.3. MAIZE

In 1970 a large number of high-lysine maize cultivars introduced from Italy (34), Venezuela (7) and CIMMYT, Mexico (1), had been tested for general performance and yielding capacity. Most of the Italian introductions were very poor in appearance, did not form ears and produced small quantities of seed if any. Eight cultivars, producing 30-90 g of seeds per plant, were saved for further testing. The Venezuelan cultivars and the CIMMYT-composite did very well and produced large quantities of seed. All were saved for further experiments.

In 1972 an experiment was initiated to trace differences in yielding capacity, protein and lysine content between the sixteen remaining cultivars. Due to bad weather conditions this trial was a complete failure.

Only two of the Italian cultivars (W64A-fl₂ and W182B-fl₂) entered the next experiment, together with the eight Latin-American varieties Simeto opaco-2, Sicarigua Mejorado opaco-2, Foremaíz-1 opaco-2, Tunapuy opaco-2, Venezuela 1 opaco-2, Compuesto opaco-2 No. 1 and Compuesto opaco-2 No. 2 from Venezuela and Composite KC2 from CIMMYT, Mexico. The varieties were arranged in complete randomized blocks replicated six times. Plots consisted of 5 rows of eight plants each, spaced 30 x 90 cm. One of the replications was abandoned and its plants used for infilling of the remaining plots.

Average grain yields of the Latin-American introductions varied from 2.5-3.3 kg/plot, or 2300-3050 kg/ha. W64A and W182B produced only 0.8 and 0.9 kg/plot (700 and 800 kg/ha respectively) and were excluded from statistical analysis. Composite KC2, Simeto and Tunapuy were significantly better producers than the other cultivars.

Crude protein content was determined according to Kjeldahl. The Italian introductions were far the best in this respect, average protein contents for W64A and W182B being 13.32 and 12.51 respectively. All other percentages were between 10.76 and 11.54. The average protein content of Venezuela-1 appeared significantly better than that of Sicarigua Mejorado and Foremaíz-1. Analysis of protein composition is still in progress.

GAM

15. SILVICULTURE

15.1. NATURAL REGENERATION

Most of the research on natural regeneration is conducted in two projects, viz. 65/3 and 67/9. The first one concerns a field trial laid down in relatively lightly exploited high rainforest, and consists of two adjacent blocks of 10.88 ha, each with a different refinement as first treatment, i.e. poisoning of weed trees with diameter limits of 10 and 20 cm respectively. In either block six treatments are being compared in eight replications. They comprise liberations of valuable poles with a girth exceeding 10 cm, applied at different times over a period of 12 years. In the year under review the schedule of recording was altered. Some items have been omitted; from now onwards records will be taken once every two years.

The second project (67/9), an experimental plot with 25 sub-plots of one hectare each was laid down in 1967 in exploited high rainforest at Mapanecreek. The experiment has already been described in former annual reports. This year treatments were applied to the five sub-plots that had not yet been liberated, and records were taken. Henceforth all 25 sub-plots will be recorded once a year as scheduled. Numbers of valuable poles with a diameter exceeding 2 cm at breast height vary between sub-plots from about 80 to 160 per hectare, a rather low stocking level. The growth rate appeared to have decreased somewhat and differences between the low levels of refinement were not as marked as in previous years. Occasionally a considerable number of newly recruited poles of the valuable and uncommon species *Fagara pentandra* was registered, indicating a good mast some years before.

NRG

15.2. PLANTATIONS

This year records were taken in the spacing and thinning trial with *Pinus caribaea* MORELET (65/1) (see CELOS Bulletins, 5, 8 and 13), and the first thinning treatment was applied as scheduled.

Research on root morphology and root development of *Pinus caribaea* MORELET (66/2) was continued. Besides this a new project (72/13) was started comprising a study of the root development of *Virola surinamensis* (ROL.) WARB., a commercially important species of Surinam's coastal swamp forests. It has previously proved impossible to establish nursery seedlings in the tree's natural habitat as transplants do not survive inundation of the root system. Though planting at better drained sites proved possible mortality rates were often high. A study of the requirements of the tree's root system is being made by means of excavation and pot experiments. Preliminary field observations indicate that in water-logged soil root penetration for some depth is very well possible, whereas so far pot experiments have shown that inundation of the root system of young plants need not be lethal. Some form of gas exchange through the roots is indicated by lenticels developing abundantly on the swollen stem base.

NRG

16. SOIL AND CROP ANALYSIS

During 1972 the chemistry laboratory was finished. Before routine analysis can be done, it is to be decided what procedures are to be followed. This is especially important for chemical analysis of soils, since the meaning and interpretation of results largely depend on the method used.

Each analytical determination, however, demands some adaptation to the laboratory conditions and to the equipment used and must therefore be tried out.

16.1. THE INFLUENCE OF EXPERIMENTAL CONDITIONS ON THE DETERMINATION OF CATION EXCHANGE CAPACITY AND EXCHANGEABLE CATIONS (71/25)

The ammonium acetate method, particularly the percolation procedure, was chosen for the determination of cation exchange capacity (CEC) and exchangeable cations. The effect was examined of the concentration of ammonium acetate, time of percolation, the amount and texture of the sand with which the soil is mixed and the amount of soil to be used. For the soils from the Surinam interior the method was standardized as follows.

1. A NH_4OAc -concentration of 1 N;
2. 80 grammes of sand finer than 600 microns;
3. 25 grammes of soil;
4. Percolation times of 24 hours, 7 hours and 24 hours for ammonium acetate, ethyl-alcohol and calciumchloride respectively.

The method presently being developed by the Royal Tropical Institute at Amsterdam, is intended to be introduced as soon as it has fully been worked out.

BHJ

16.2. SHORT INVESTIGATIONS ON METHODS OF SOIL ANALYSIS

16.2.1. ORGANIC MATTER

A comparison was made between the loss-on-ignition method and the method of Kurmies and of Walkley-Black. Loss-on-ignition proved unusable. The C figures obtained with Kurmies were 1.12 times as high as those obtained with Walkley-Black. The latter method was chosen because of its simplicity.

Multiplication of the C content according to Walkley-Black by 2 gives organic matter content. The conversion factors used are:

- 1.12 for the conversion of Walkley-Black C to Kurmies C;
- 1.03 for Kurmies C to elementary C;
- 1.72 for C to organic matter.

16.2.2. PH

Some experiments were carried out to investigate the effect of (i) shaking time, (ii) position of the shaking bottles and (iii) the placement of one or both electrodes either in the clear supernatant following sedimentation or in the suspension immediately upon shaking.

One hour of shaking proved sufficient. When the bottles were placed horizontally the variation between replicates was less than when placed vertically. The pH in the clear supernatant was 0.1-0.2 units higher than in the suspension. For reasons of time

saving it was decided to measure henceforward in the suspension.

Only pH-KCl will be determined for routine purposes.

16.2.3. PHOSPHORUS

The method Bray I (0.03 N NH_4F and 0.025 N HCl) was compared with the Olsen method (0.5 M NaHCO_3).

The Olsen method gave lower P values, often zero. Since the Bray method has the additional advantage of being simpler it was chosen for the time being as the routine method.

For the colorimetric determination of P the molybdenum blue method with ascorbic acid and potassium antimonyltartrate is used (716 nm). The standard solutions run from zero to 5 ppm P.

BHJ

16.3. SHORT INVESTIGATIONS ON METHODS OF CROP ANALYSIS

16.3.1. GRINDING OF MAIZE KERNELS

Usually, dried plant material is ground before being digested. Much labour can be saved by digesting whole grains. Though this has been proved possible for small seeds it is questionable whether this also applies to intact maize kernels. Standard-size samples of 300 or 600 mg contain at the most four maize kernels, a number which is probably too low to provide a representative sample.

The results of the analysis of 12 samples of ground maize were compared with those of intact grains.

The N content was significantly higher for the ground samples (average 1.823 vs. 1.754%), whereas the coefficient of variation was only 1.6% for the ground samples vs. 6.7% for intact grains. About the same held for P. For K some extreme values were obtained in the case of intact grains. It was concluded that for reliable analyses maize kernels need to be ground.

BHJ

17. SOIL FERTILITY AND PLANT NUTRITION

17.1. A STUDY OF THE NUTRITIONAL STATUS OF *Pinus caribaea* MORELET BY MEANS OF THE TECHNIQUE USED FOR THE ASSESSMENT OF SUFFICIENCY QUOTIENTS (71/22)

An experiment was conducted to investigate whether the pot experiment technique used for the measurement of sufficiency quotients is suitable for studying nutritional problems in *Pinus*.

In September 1971 young *Pinus* plants were transferred with soil from nursery bags to pots with a gauze bottom. The pots were placed on containers with different nutrient solutions: complete solution or solutions without N, P, K, Ca, Mg, Fe, B or Cu. The roots grew through the gauze and reached the solution below within three to seven weeks. Differences in growth and deficiency symptoms, appearing some weeks later, became more pronounced with time.

The plants' habit and the deficiency symptoms can be summarized as follows:

complete solution: initially a strong longitudinal growth, later more branching.

minus N: little longitudinal growth, no branches; whole plant yellowish-green; very long roots.

minus P: little longitudinal growth, few branches.

minus K: little longitudinal growth and few branches; after half a year needle tips turned brownish and dried up; short roots.

minus Ca: aerial parts without special symptoms, strong longitudinal growth and branching; short roots.

minus Mg: after two months needle upper halves turned yellowish and some months later brownish; longitudinal growth, branching and roots as for plants on complete solution.

minus Fe: longitudinal growth as for plants on complete solution; branches initially pale green, later "normal" green; roots were brittle and root tips broke off.

minus B: rather little longitudinal growth; growing point destroyed; branches, curved upwards, appeared at about the same height immediately below the stem's top; upper needles; crowded and somewhat misformed; short roots.

minus Cu: no special symptoms.

The experiment was terminated on 29 June. The trees were separated into stems, branches, roots from soil and roots from solution, then dried and analysed for N, P, K, Ca and Mg. The chemical data have not yet been elaborated.

BHJ

17.2. A SOIL FERTILITY SURVEY OF SOME SOILS IN THE INTERIOR OF SURINAM (71/28)

Little is known about the fertility of the soils in the Surinam interior. The use of soil maps for information on soil fertility is hazardous as long as it is not known whether there is a relation between soil type and soil fertility and if so, which soil characteristics are decisive.

A study of this relationship has been planned for those Surinam soils that also occur in large areas elsewhere in the tropics. Since it is not possible to include all units concerned, the actual research is preceded by a survey to find out where the most interesting soils are, entailing chemical analysis of crop plants from trials and plantations,

and the carrying out of small fertilizer trials.

Sorghum grain samples taken in 1971 at Baboenhol (70/28) were analysed. The grain N contents could be divided into three groups: lower than 1.7%, between 1.7 and 1.9% and more than 1.9%. Their distribution over the field more or less matched the detailed soil map i.e. the highest N content was found on the more humic soils. Such a relation was not found for grain P and K.

On 21 January, 8 and 24 February and 18 March, also maize leaves were sampled (see section 18.2) at Baboenhol. The chemical data have not been evaluated yet.

The small fertilizer trials with maize at Victoria mentioned in the previous annual report showed great differences in emergence, growth, yield and response to fertilizers. The yields are presented in Table 27. The poor nutrient status of the loamy sand was clearly demonstrated; the basin clay proved the richest soil.

Table 27 - Maize yields at Victoria (tons/ha). Figures have been corrected for skips

soil	no fertilizer	N	NP	NPK
terrace loamy sand	0	0	0	1.5
terrace sandy clay loam	0.2	0.2	3.6	4.9
river basin clay	5.6	4.4	4.6	5.9

Leaf samples were taken on the same dates as at Baboenhol. After harvesting plants were separated into stems plus leaves, bracts, axes and grains. Only part of the chemical data were available at the close of the year.

BHJ

17.3. THE SUITABILITY OF FACTORIAL EXPERIMENTS FOR THE ASSESSMENT OF SUFFICIENCY QUOTIENTS (72/2)

The sufficiency quotient for a certain nutrient is defined as the ratio between the relative growth rates (RGR) of plants on a solution without that nutrient and those on complete nutrient solutions (CELOS Bullerins, 16, p. 37).

When more than one nutrient is under study factorial designs look attractive because of the saving of material and labour. On the other hand it is questionable whether such designs can be used in this type of experiments. It seems likely that the growth reduction caused by the omission of one nutrient masks the effects of the omission of a second one. Besides, difficulties arise with the definition of sufficiency quotient. For instance, it may be questioned as to whether in a 2-factor experiment with N and P $SQ_N = RGR_N/RGR_C = RGR_{NP}/RGR_P$ in which RGR_C , RGR_N , RGR_P and RGR_{NP} denote the relative growth rates of plants on a complete solution and solutions without N, P and N + P respectively.

A 2³ factorial experiment with N, P and K as factors was set up. The test crop was maize (collection no. 69343). The soils were: (1) a heavy clay from CELOS, rather rich

in N and K, but moderate in P; (2) a sandy ridge soil, poor in N and K, and moderate in P; and (3) a white bleached coarse sand of the so-called Zanderij formation, extremely poor in N, P and K.

The nutrient which was in shortest supply in the soil proved to govern the relative growth rate of plants on solutions from which more than one nutrient had been omitted. It was concluded that factorial experiments are not useful for the assessment of sufficiency quotients.

BHJ

17.4. SOIL FERTILITY OF SOME FLUVIATILE SOILS AT VICTORIA (72/14)

The big differences in soil fertility found at Victoria (see section 17.2) made a more detailed study of these soils worthwhile.

Fertilizer trials, consisting of half a replicate of a 2^4 factorial experiment with N, P, K and lime as factors, were laid down on two terrace loamy sands and one river basin clay loam. The fertilizer rates were 120 kg N, 90 kg P_2O_5 and 120 kg K_2O per ha split in three equal applications. All lime was applied at once, rates being 3000 kg $CaCO_3$ per ha on the sandy soils and 4000 kg on the silty clay loam. A trial of a central composite second order design was carried out on a terrace sandy clay loam. The levels were 0, 40, 80, 120 and 160 kg N; 0, 30, 60, 90 and 120 kg P_2O_5 ; 0, 40, 80, 120 and 160 kg K_2O and 0, 1400, 2800, 4200 and 5600 kg $CaCO_3$ per ha.

Maize was sown in June and harvested in October. Samples of the 6th leaf were taken on 2 August.

The trial on terrace sandy clay loam was almost entirely lost by a series of accidents and bad luck. However, the main cause of its failure was poor drainage. From growth records it could be concluded that the best responses were obtained for N and P. According to rough estimates yields did not exceed 2.5 tons/ha and were often much lower. The trial on the basin clay loam was mutilated by many skips, which also were caused by waterlogging. Nitrogen and liming seemed most important. Yield estimates were between 2 and 3.5 tons/ha. The yields on the loamy sands varied between zero and 1.6 tons/ha. Both, P-dressing and liming proved indispensable.

Late July and after harvest, in November, soil samples were taken in both, the completely fertilized and limed and in the control plots of each trial, at depths of 0-10, 20-30 and 50-60 cm. They are being analysed at the Royal Tropical Institute, Amsterdam, and at CELOS to trace the displacement of fertilizers through the profile and to study the influence of liming on the behaviour of Al in the soil.

BHJ

17.5. AN EVALUATION OF SOILS AT COEBITI (72/19)

More information is required on the productivity and fertilizer needs of the soils at Coebiti, an experimental garden in the interior of Surinam. The soils vary from completely bleached white coarse sands to brown and yellow sandy loams and sandy clay loams. To study the relation between soil fertility and soil type, fertilizer trials were laid down on seven of the nine soil types distinguished, two soils being too wet for agricultural use. On parts of one of the sandy and one of the loamy soils where the kudzu grew very poorly, a second series of trials was laid down. The poor growth was probably a result of soil compaction caused during mechanical clearing.

First occupation. The design was similar to that used at Victoria (see section 17.4). From three trials, representing poor, medium and good conditions, soil samples

were taken for the study of fertilizer displacement; place and depth of sampling were as at Victoria.

Maize was sown at the beginning of July and harvested in November. Samples of the 8th leaf were taken on 7 August.

Emergence was satisfactory (ca. 90%) in all trials, but growth differed much. Average yields were 1.0 ton on white and 1.5 tons on brown sand, 1.2 tons on loamy sand and about 2 tons per ha on sandy loams. Where compaction occurred yields were as low as 0.4 ton on brown sand and 0.7 ton on sandy loam.

The response to P fertilizer was high in five, low and statistically not significant in three trials and slightly negative in the trial on the white sand. Only on the latter soil type a significant response to K and to liming was obtained. The effect of nitrogen was not clear, a significant positive effect being obtained only in one trial on sandy loam.

Second occupation. On the three sites that had shown a low response to P in the first occupation the same experimental design was used. On the other ones a 2³ factorial experiment was laid down with N, K and lime as factors. In this case all plots received phosphorus to prevent severe P deficiency from masking possible effects of N, K and liming. Since the pH on the plots limed in the previous occupation was still high liming was not repeated. N, P and K rates were as before. The trials were planted in the second half of December.

BHJ

17.6. A COMPARISON OF THREE VICTORIA SOILS WITH A DUTCH AND A TURKISH SOIL BY MEANS OF SUFFICIENCY QUOTIENTS (72/26)

Table 28 - Sufficiency quotients of N, P, K, Ca and Mg. Sequence of soils for each nutrient in order of SQ-values

nitrogen		phosphate		potassium		calcium		magnesium	
soil	SQ ¹⁾	soil	SQ	soil	SQ	soil ²⁾	SQ	soil	SQ
c ²⁾	0.75m	Du	0.78m	Tu	0.87m	Du	0.79m	c	0.85m
cl	0.59n	cl	0.69mn	c	0.84m	c	0.77m	Du	0.82mn
Tu	0.52np	c	0.60n	Du	0.84m	cl	0.72m	cl	0.75n
Du	0.49pq	Tu	0.57n	cl	0.61n	s	0.58n	s	0.74n
s	0.45q	s	0.57n	s	0.56n				

1. Values followed by the same letter do not differ significantly ($P = 0.05$).
2. c = clay; cl = clay loam; s = sand; Tu = Turkish soil; Du = Dutch soil.
3. The quantity of Turkish soil available was too small to determine all SQ-values.

Having established the most appropriate procedure to determine sufficiency quotients using maize as the test crop (see section 17.3 and the report for 1971), it still has to be determined how the quotients must be interpreted under Surinam conditions. The Victoria soils from section 17.2, which will be referred to as sand, clay

loam and clay, were used in a pot experiment and compared with a heavily fertilized Dutch loamy sand and a Turkish clay loam poor in P, medium in N and high in K, Ca and Mg. The nutrient solutions were: complete, minus N, minus P, minus K, minus Ca and minus Mg. The experiment was replicated four times and carried out in the screenhouse in October.

On the sand emergence and initial growth were retarded. In all minus-Ca solutions root development was stunted. When the experiment was terminated a number of plants were divided into above-ground parts, roots from soil and roots from solution, and subsequently dried. The analyses have not been completed yet.

In Table 28 the SQ-values have been summarized. The clay proved rich in all nutrients except in P, whereas the sand was poor in every respect. The clay loam was intermediate, but - in view of the field results (Table 27) - surprisingly high in P. However, it had already been found that this type of pot experiment is not very suitable to assess P availability. The ratings of the Dutch and Turkish soils were as expected.

BHJ

17.7. THE EFFECT OF SPLIT-APPLICATION OF FERTILIZERS IN MAIZE (72/24)

The soils of the Coesewijne formation are characterized by a low CEC so that fertilizers may be rapidly leached when applied under rainy conditions.

To find out whether in maize under these circumstances split-applications of fertilizer would improve growth and grain production a trial was set up comparing various split treatments. The experiment was laid out in two blocks, one on sandy loam the other on sand. The different treatments were (i) all fertilizer at planting, (ii) 2/3 at planting and the rest three weeks later, (iii) as (ii) but the rest seven weeks after planting, (iv) 1/3 at planting and the rest three weeks later, (v) as (iv) but the rest seven weeks after planting. All treatments were replicated twice in both blocks. Plots consisted of 6 x 15 plants, spaced 30 x 90 cm. Each block was surrounded by two guard rows. The total quantity of fertilizer applied amounted to 120 kg N, 90 kg P₂O₅ and 120 kg K₂O per ha. Before planting 3000 kg CaCO₃/ha in the form of Emkal was applied.

Great differences were recorded in emergence, plant performance and kernel yield between the replicates on both sand and loam. Emergence was about 70% on sand and 85% on sandy loam. Average plant height 6 weeks after sowing varied from 59-86 cm, on sand whereas on sandy loam values between 95 and 149 were recorded. Differences between blocks were so large that they had to be analysed separately. On sand no clear growth differences were visible between treatments. All performed badly and showed deficiencies of nitrogen, phosphorus, potassium and iron. Kernel yields varied from 2.3-2.4 kg per plot, which is equal to 470-710 kg per ha. No statistically significant differences were found between treatments.

On sandy loam the treatment "all fertilizer at planting" performed worse than all the others in every respect. Deficiency symptoms were found only occasionally. Kernel yields varied from 7.7 to 14.3 kg per plot or 1600-2940 kg/ha. The two treatments "2/3 at planting and the rest seven weeks later" and "1/3 at planting and the rest three weeks later" were significantly better than "all fertilizer at planting".

GAM

18. TILLAGE

18.1. A COMPARISON OF TILLAGE AND MINIMUM TILLAGE SYSTEMS ON HEAVY CLAY SOILS FOR THE CONTINUOUS GROWING OF ANNUAL CROPS (70/25)

The trial as described in the report for 1970 was continued in the year under review with rice, grown in the period March to August, and with maize and soyabeans from September till December. (For details the reader is referred to CELOS Bulletins, 13, p. 40.)

The rice (cv. Apani) planted in 25-cm rows, was sown mechanically on 30 March with a 2.25 m wide tractor-drawn sowing machine. Emergence and subsequent growth were satisfactory. Fertilizing took place on 27 April and on 29 and 31 May, a total of 450 kg NPK (15+15+15) being applied per ha. Weeds were controlled by hand hoeing. The crop was harvested between 27 July and 1 August, and threshed mechanically following some drying in the field. Some treatment effects are presented in Table 29.

Table 29 - Tillage operations and plant growth (rice cv. Apani)

	rotavating	ploughing	minimum tillage
weed control (h/ha)	319	203	437
plant height on 14 July (cm)	90	93	70
yield (tons/ha; 15% moisture)	2.96	3.59	1.51

With weeding time being lowest and yield highest ($P < 0.01$) ploughing appeared to give the best results.

Tillage for the second period of occupation started at the middle of September. The crops were sown mechanically on 20, 21 and 28 September, maize being planted in 90-cm rows, soyabeans in 45-cm ones. After sowing the soil was pressed with a Cambridge roller. For soyabeans fertilizer was applied at the beginning and the end of October at a rate of 200 kg NPKMg (13+13+18+2) per ha. The maize was fertilized at the beginning of October at a rate of 450 kg NPKMg (13+13+18+2) per ha and at the end of November at rates of 100 kg urea and 75 kg double superphosphate per ha.

Emergence of both crops was satisfactory. Weeding between the rows was done mechanically with a small tractor at which a tool carrier with three shovels was mounted (capacity 0.15 ha/h). Weed control in the row was by hand hoeing. The maize was sprayed once with Dipterex SP 95 against *Lophygma frugiperda*. Though the soyabeans were rather heavily attacked by *Ceratoma variegata*, control measures were not considered necessary.

The soyabeans were harvested by hand at the beginning of January 1973, the maize at the end of that month. Both crops were threshed mechanically, after which the seed was artificially dried. Some treatment effects are presented in Table 30.

For maize the average yield was lower than the year before, whereas the soyabeans yielded about the same. Though for both crops ploughing gave the highest yields, the differences were not statistically significant.

Table 30 - Tillage operations and yield (soyabeans and maize)

	rotavating	ploughing	minimum tillage
soyabeans			
number of productive plants per metre row	5.6	6.2	5.9
yield (tons/ha; 15% moisture)	0.87	1.11	1.01
maize			
number of productive plants per metre row	3.5	3.4	3.0
yield (tons/ha; 15% moisture)	2.57	2.96	2.10

TS

18.2. A COMPARISON OF TILLAGE AND MINIMUM TILLAGE SYSTEMS ON SANDY LOAMS FOR THE CONTINUOUS GROWING OF ANNUAL CROPS (70/28)

The trial as described in the previous annual report though somewhat modified was continued in the year under review. To decide upon the best crop for each season five crops were grown per occupation instead of a single more or less arbitrarily chosen one. They included maize, sorghum, soyabeans, cowpea and green gram (*Phaseolus aureus*).

The quantities of fertilizing materials applied that were expected to be adequate for good crop growth are listed in Table 31.

Table 31 - Quantities of minerals for the various crops (kg/ha)

crop	mineral		
	N	P ₂ O ₅	K ₂ O
maize	56	39	53
sorghum	19	28	17
soyabeans	16	25	32
cowpea	17	25	30
green gram	17	26	32

For all crops the mixture NPKMg (10+15+20+2) was used, the total amount being split in three applications except for maize which was fertilized four times. A very small amount of fertilizer was placed next to the seeds. Of the remainder half was given at about 10 days, the other half at about 40 days after sowing. The maize was top-dressed with urea at a rate of 75 kg/ha sixty days after sowing.

All crops were sown mechanically with a 2.25 m wide tractor-drawn sowing machine. The amounts of seed used and the row distances for the various crops are given in Table 32. To obtain a better suppression of grass weeds crops were sown more narrowly in the second period of occupation.

Table 32 - Amounts of seed and row distances for the various crops

crop	seed quantity (kg/ha)	row distance (cm)	
		1st and 3rd occupation	2nd occupation
maize	35	90	75
sorghum	10	45	37.5
soyabeans	27	45	37.5
cowpea	33	45	37.5
green gram	25	45	37.5

Thinning in the first period of occupation, carried out by hand, resulted in too low a plant density of all legumes, thus adversely affecting yield and enhancing weed growth. In the following occupations only maize and sorghum were thinned.

The crops were mechanically weeded with a small four-wheel drive horticultural tractor at which a tool carrier with three shovels was mounted (capacity 0.15 ha/h).

Crop yields at the various tillage system in the three periods of occupation are listed in Table 33.

Table 33 - Crop yields (kg/ha) and sowing and harvesting dates

crop	yields			sowing date	harvesting date
	rotavating	ploughing	minimum tillage		
occupation I					
maize	1139	1054	1674	15/12 ²⁾	6/4
sorghum	n.r. ¹⁾	806	690	15/12	22/3
soyabeans	55	185	79	15/12	30/3
cowpea	504	586	390	15/12	28/2
green gram	128	83	n.r.	15/12	15/2
occupation II					
maize	n.r.	n.r.	n.r.	25/4	30/8
sorghum	143	132	n.r.	25/4	3/8
soyabeans	150	440	248	25/4	14/8
cowpea	478	282	328	25/4	12/7
green gram	n.r.	n.r.	n.r.	25/4	4/7
occupation III					
maize	—	—	—	28/9	—
soyabeans	—	—	—	28/9	—
cowpea	780	812	604	29/9	21/12
green gram	372	280	346	29/9	21/12

¹⁾ n.r. — not recorded; less than 50 kg/ha

²⁾ 1971

The yield levels varied from moderate to nil, the most important reason, for this being the powerful growth of grass weeds. On the whole mechanical weeding proved inadequate, rain immediately after the operation enabling the grass to root again, so that weed growth was only slowed down. Mechanical weeding in the dry season (third occupation) proved adequate only where the crop grew well.

Drainage, water shortage in the seedling stage and diseases were other problems encountered in this trial.

The yield level of the maize in the first occupation was rather low; at harvest time there were many weeds in the crop. In the second occupation the yield was negligible due to waterlogging (small plants, light coloured leaves), whereas in the third occupation germination and emergence were adversely affected by drought; no rain was recorded during the first three weeks after sowing.

The sorghum was affected by a disorder in the seedling stage which considerably reduced plant population. It probably is caused by insects and occurs very locally. As a result it was decided not to sow sorghum in the third occupation.

The yields of soyabean were generally very low. Due to the fact that the plants shed their leaves about ten days before ripeness, the weeds overgrew the crop thus hampering harvesting. In the third occupation germination and emergence of this crop were also very poor.

Cowpea yields varied from moderate to reasonable, this crop being able to compete with the weeds, especially in the third occupation when a completely closed canopy was obtained. Cowpeas proved most suitable for the soils concerned.

The yields of green gram varied from nil to very moderate. This crop prefers a dry soil; in the wet season many plants died due to water-logging and fungal diseases. In the third occupation, which was rather dry, not too bad a crop was produced which competed well with the weeds. However, most of the seed did not germinate until the onset of the next rains i.e. three weeks after sowing. This explains the late harvesting date.

Since the trials were not replicated it is not possible to decide on the best treatment for a particular crop. The minimum tillage treatment always suffered from excessive weed growth. In the other treatments the grass weeds appeared somewhat later and were less abundant.

TS

19. METEOROLOGICAL OBSERVATIONS

Table 34 - Rainfall and sunshine at CELOS during 1972 (thirty-year means at Cultuurtuinlaan, Paramaribo)

month	rainfall (monthly total, mm)		sunshine* (daily mean, %)	
	1972	1942-1971	1972	1941-1970
January	352	205	32	49
February	127	156	47	51
March	189	129	39	54
April	247	190	38	50
May	368	322	33	45
June	266	315	41	51
July	212	209	54	62
August	191	162	69	70
September	113	92	68	76
October	122	87	77	76
November	205	111	46	65
December	176	162	39	50
Total	2568	2140	—	—
Mean	—	—	49	28

* From Campbell Stokes Recorder

RELATÓRIO ANUAL DO CENTRO DE PESQUISAS AGRÍCOLAS DO SURINAM (CELOS), REFERENTE AO ANO DE 1972

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O aumento das tarefas de ensino impostas ao corpo científico da Universidade de Agronomia de Wageningen da Holanda resultou, no decorrer do ano que ora se analisa, numa diminuição do número de elementos do corpo administrativo que coadjuvavam o CELOS. Todavia, o Centro continuou a alargar a sua zona de actividades.

Os ensaios feitos com uma série de bombas portáteis de fabrico local constituíram as actividades relativas à engenharia agrícola no ano de 1972.

Os trabalhos no âmbito da produção de cereais restringiram-se a duas experiências preliminares feitas com a ervilha de boi.

Estudou-se, numa delas, a formação do fruto e o enchimento da vagem. Noutra, investigou-se a relação entre o índice de superfície da folha e a produção da matéria seca.

A investigação no campo da produção de cereais foi, por outro lado, mais completa. Foram feitas experiências de espaçamento, parte das quais, levadas a cabo para se determinar a utilidade dos desenhos do leque nos grãos preto e verde, amendoim, soja, ervilha de boi, sorgo e arroz. O amendoim, grão verde e soja foram, também, objecto de experiências comparativas de produção. O mesmo em relação à mandioca, mas neste caso a época das colheitas é um segundo factor variável na experiência. Realizaram-se, além disso, três ensaios de herbicidas relacionados com diversos herbicidas (em parte, de pré-emergência) e várias colheitas anuais.

Investigou-se também, num ensaio preliminar, se as leivas podem servir como meio de colheitas de crescimento anual em terrenos pesados e mal drenados, durante as estações chuvosas. As últimas mas não menos importantes experiências iniciaram-se a fim de se estudar as possibilidades de crescimento do amendoim, da soja e do grão verde no terreno arenoso da cintura costeira do sul do país.

Tal como em anos precedentes, os ensaios entomológicos concentraram-se nos roedores do arroz *Diatraea saccharalis* e *Rupela albinella*, sendo dado ênfase, novamente, aos estudos da história da vida das duas espécies e de alguns dos seus parasitas.

Em 1971, começou-se um estudo de administração de herdades para se reunir informação acerca da produção de vegetais e frutos no Suriname. Os trabalhos no campo continuaram até Agosto. Fez-se, em seguida, a sistematização e análise dos dados, trabalho árduo que levará, pelo menos, um ano inteiro, a ser efectuado.

Subsistiu a mais importante objectivo da pesquisa da ecologia das florestas, começado em 1965 com a fim de se reunirem dados acerca do afolhamento das florestas em terrenos baixos inundados pelas chuvas por meio dum registo periódico da vegetação em permanentes lotes de terreno situados em áreas desflorestadas, em terras abandonadas após a mudança de cultivos, e em florestas exploradas e virgens. Continuaram, também, as investigações sobre a propagação natural da *Cecropia* spp.

No campo das técnicas de silvicultura, as investigações restringiram-se a aspectos concernentes às relações entre o homem e o trabalho nas florestas tropicais. Foram orientados estudos fisiológicos de trabalho e de tempo no que diz respeito à munda em plantações de jovens *Pinus caribaea*. Em contraste com os anos precedentes, utilizaram-se instrumentos sofisticados para os vários cálculos.

Continuaram-se os estudos comparativos com diferentes ferramentas manuais hortícolas e agrícolas, começado em 1971.

Como no ano anterior, submeteram-se a confronto as ferramentas de mondar e de ceifar em termos de esforço físico dispendido no seu uso, enquanto que as ferramentas de monda foram também comparadas quanto a diferenças de rendimento.

Os estudos de hidrologia relacionaram-se com a medição da evapo-transpiração por meio dum lisímetro pesável e um ensaio quanto à relação entre a radiação de entrada de onda curta e a relativa duração da luz solar.

As experiências de irrigação começaram numa plantação de limoeiros nos terrenos arenosos ao sul da zona argilosa costeira.

Presume-se que uma irrigação adicional possa ser benéfica nesta área ao neutralizar déficits de humidade do solo durante os períodos de seca.

Como parte do estudo da produção e compra e venda de legumes e fruta efectuaram-se estudos, e entrevistaram-se negociantes e clientes no mercado central de Paramaribo durante um período de 2 meses. Além disso foi empreendido um estudo orçamental por um número de famílias a fim de se investigar o comportamento do consumidor em relação a estas mercadorias.

No que se refere à pesquisa da reprodução de plantas, continuou-se o estudo do fruto em formação na batata doce, afectado pela incompatibilidade e esterilidade.

Fizeram-se progressos nos trabalhos de reprodução para se chegar às variedades sintéticas do milho, ao mesmo tempo que um programa de selecção periódica da mesma produção forneceu resultados esperançosos.

Concluíram-se diversas experiências relativas ao conteúdo e qualidade de proteína em colheitas de importantes alimentos tropicais. Obtiveram-se, como resultado, valiosas informações referentes a proteínas presentes em produtos como a batata doce, o sorgo, o milho e vários legumes.

A pesquisa no campo da silvicultura compreendeu os ensaios de regeneração natural que datam de 1965 e 1967, o ensaio referente ao espaçamento e adelgaçamento verificado com o *Pinus caribaea* que data igualmente de 1965, e os estudos feitos à morfologia e desenvolvimento da raiz do *Pinus caribaea* e da *Virola surinamensis*.

Os trabalhos respeitantes à fertilidade do solo e nutrição das plantas abrangeram certos tópicos como o uso do trigo para a avaliação de quocientes de suficiência, um exame à fertilidade do solo em determinados terrenos no interior do país, uma avaliação da produtividade e necessidade de fertilizadores dos diferentes solos num jardim experimental recentemente inaugurado, o efeito da "split application" sobre fertilizantes no milho, e experiências relativas a processos de laboratório.

Este ano, o arroz das regiões montanhosas do interior (grande estação chuvosa) seguido do milho e da soja (grande estação seca) foi cultivado num ensaio de fertilidade a longo prazo começado em 1970, a fim de se estudar o efeito da grande e pequena cultura num terreno costeiro argiloso e pesado sob colheita permanente. Um semelhante ensaio iniciado em 1971 num solo leve e arenoso na zona da savana do Suriname, teve continuação, sob uma forma algo modificada, com várias colheitas anuais.

INFORME SOBRE EL EJERCICIO 1972 DEL CENTRO DE INVESTIGACIÓN AGRÓNOMA EN SURINAM (CELOS)

El agravamiento continuo de la tarea de enseñanza impuesta a los miembros del personal científico de la Universidad de Agronomía en Wageningen, Holanda, resultó en una disminución del número de científicos destacados en el CELOS durante el año que reseñamos. Aun así el Centro continuó desplegándose.

En el terreno de la técnica agrónoma se ensayó una serie de bombas de irrigación portátiles de construcción local.

Las actividades en el campo de la fitotécnica se restringieron a dos experimentos preliminares en frijoles. En el primero se estudió la fructificación y el número de semillas en las cáscaras; en el segundo se examinó la relación entre el índice de la superficie de las hojas y de la tierra ocupada por la planta (leaf area index) y la producción de materia seca.

Se hicieron muchas investigaciones sobre la productividad de plantas. Experimentos de espaciamiento se hicieron en tipos verde y negro de judías de mungo, cacahuètes, soja, sorgo granero y arroz. Una parte de esas investigaciones tuvo por objeto averiguar la utilidad eventual de diseños en forma de abanico (fan designs). Cacahuètes, judías de mungo verdes y soja asimismo se usaron en experimentos de comparación de cosecha. En el caso de la yuca la edad de las plantas en tiempo de cosecha, además de la producción, era un factor variable.

Tres ensayos fueron realizados relacionado con varios yerbicidas y diferentes plantas anuales. Además se probó en una investigación preliminar si los caballones sirven para cultivar plantas anuales en suelos fuertes e insuficientemente drenadas durante la temporada de lluvia. También se empezaron investigaciones para averiguar las posibilidades del cultivo de cacahuètes, soja y judías de mungo verdes en tierras arenosas de la zona sabanera.

Como en los años pasados las investigaciones entomológicas tendieron al estudio de los barrenadores de arroz, *Diatraea saccharalis* y *Rupela albinella*. Se prestó mucha atención a los estudios de la biología de las dos especies y algunos de sus parásitos.

El estudio de la economía en un número de empresas agrícolas, empezado en 1971 para intentar obtener mejores informaciones en la producción de verduras y fruta, se concluyó en agosto del año que reseñamos. Después se comenzó a elaborar y analizar los datos recogidos.

Conseguir informaciones sobre la sucesión vegetal del bosque humedo de la zona baja, siguió siendo el objetivo principal de los estudios en ecología forestal. Con este fin, a partir de 1965 se levanta periódicamente la vegetación de parcelas permanentes ubicadas en terrenos desforestados, en conucos abandonados, en bosques explotados y en bosques vírgenes. Además se continuó la investigación de la propagación natural de *Cecropia* spp.

En cuanto a la explotación forestal las investigaciones se limitaron a problemas referentes a la relación entre hombre y labor en bosques tropicales. Se hicieron estudios de tiempo y de la fisiología de trabajo, referentes al desyerbo en plantaciones de pino caribe joven. En contraste a los años precedentes, refinados instrumentos de medida estuvieron a la disposición del investigador.

Se continuaron los estudios comparativos con varios tipos y modelos de herramientas agrícolas y jardineras empezados en 1971. Así como en el año precedente se registró el esfuerzo físico usado al trabajar con diferentes utensilios para segar y para desyerbar.

En cuanto a las herramientas de desyerbo además se hizo una comparación de la calidad y cantidad de la labor realizada.

En el trabajo hidrológico se dedicó mucha atención a la medición de la evaporación con un lysímetro. Otro tópico de mayor importancia fue una investigación sobre la relación entre la radiación de ondas cortas —medidas con ayuda del Kipp-solarímetro— y el tiempo de sol relativo.

Se iniciaron experimentos en un plantío de naranjes en los suelos arenosos al sur de la zona arcillosa costera. Se supone que la irrigación suplementaria pudiera ser favorable en esta región para suprimir las deficiencias de agua del suelo en períodos secos.

Como parte de los estudios sobre la producción y la comercialización de legumbres y fruta se hicieron observaciones y entrevistaron a comerciantes y compradores en el mercado central de Paramaribo por un espacio de dos meses. Además se emprendió un estudio presupuestario en un número de familias para intentar averiguar el comportamiento del consumidor en cuanto a estos artículos.

En el campo de mejoramiento de plantas se continuaron las investigaciones sobre como la fructificación en batatas es afectada por incompatibilidad y esterilidad. Los ensayos para llegar a variedades sintéticas productivas de maíz se adelantaron de nuevo. Además un programa de selección repetida en la misma especie produjo resultados que prometen mucho.

Se terminaron varios experimentos acerca del contenido y de la calidad de proteínas en unas de las principales plantas cultivadas de la zona tropical. Los cuales produjeron datos útiles sobre las proteínas que se encuentran en especies de plantas como batatas, sorgo granero, maíz y diversas leguminosas.

Con relación a la silvicultura se siguieron los estudios sobre la regeneración natural del bosque mesofítico que habían sido empezados en 1965 y 1967, así como el ensayo de espaciamiento y raleo en pino caribe y los exámenes sobre el desenvolvimiento y la morfología de las raíces en *Pinus caribaea* y *Virola surinamensis*.

Las investigaciones en el terreno de pedología y fertilidad de los suelos tuvieron como tópicos mayores el estudio de síntomas de deficiencias en el pino caribe en el que se utilizó tiestos, un examen preliminar de algunos suelos del interior de Surinam, una evaluación de la productividad y necesidad de abonos de los diversos suelos en un jardín experimental recién abierto, el efecto de aplicación dividida de abonos químicos en el maíz, y experimentos teniendo por objeto desenvolver métodos de laboratorio.

En el año que reseñamos el arroz de montaña (larga temporada húmeda) seguido por maíz y soja (larga temporada seca) fueron cultivados en un experimento empezado en 1970 estudiando el efecto de métodos diferentes de labranza sobre tierra fuerte arcillosa en un sistema de cultivación permanente. Un experimento análogo con tierra arenosa en la zona sabanera iniciado en 1971, ha sido continuado en una forma algo modificada utilizando varias plantas anuales.

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