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GROUNDNUT EXPERIMENTS AT COEBITI IN THE PERIOD 1972-1975: A SUMMARY OF RESULTS

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SUMMARY

In Suriname groundnuts are grown on sandy ridges in the coastal area. Farmers' plots are small. Labour is scarce and the possibilities for mechanization are limited. As a result the total groundnut acreage is gradually decreasing. Large areas of sandy soil occur immediately south of the coastal clay belt. They vary in texture from sands to sandy loam and seem suitable for mechanized crop production. The potential of these soils, particularly the sandy loams, for annual crops is being studied in an experimental farm named Coebiti. One of the crops is groundnuts of which various agronomic aspects have been studied so far. The present paper summarizes the main results of experiments on the subjects of liming, plant density and spacing, and *Cercospora* leaf spot control, that were carried out in the period 1972-1975.

INTRODUCTION

In Suriname groundnuts are predominantly a crop of the coastal plain where they are grown on the sandy ridges present in the coastal clay belt. As a rule these ridges are narrow and the farmers' plots small; large production units are absent. Mechanization is restricted to soil preparation and labour is scarce, rendering it difficult to farm economically. As a result the total groundnut acreage is gradually decreasing.

Outside the coastal area groundnuts are found on the garden plots of the bushnegroes living in the interior on the banks of the country's main rivers. Here the crop is grown for home consumption and does not enter local trade. Until fairly recently groundnut research therefore was confined to coastal conditions.

During the sixties the sandy soils of the Zanderij formation immediately south of the coastal clay belt gradually became accessible. Their relatively flat topography, their good soil physical properties and their presence in large areas, which all are a prerequisite for mechanization, aroused agricultural interest. In 1969 an experimental farm, named Coebiti, was laid out at about 30 km south-west of the international airport Zanderij (fig. 1). Its soils represent the various types encountered in the Zanderij formation.

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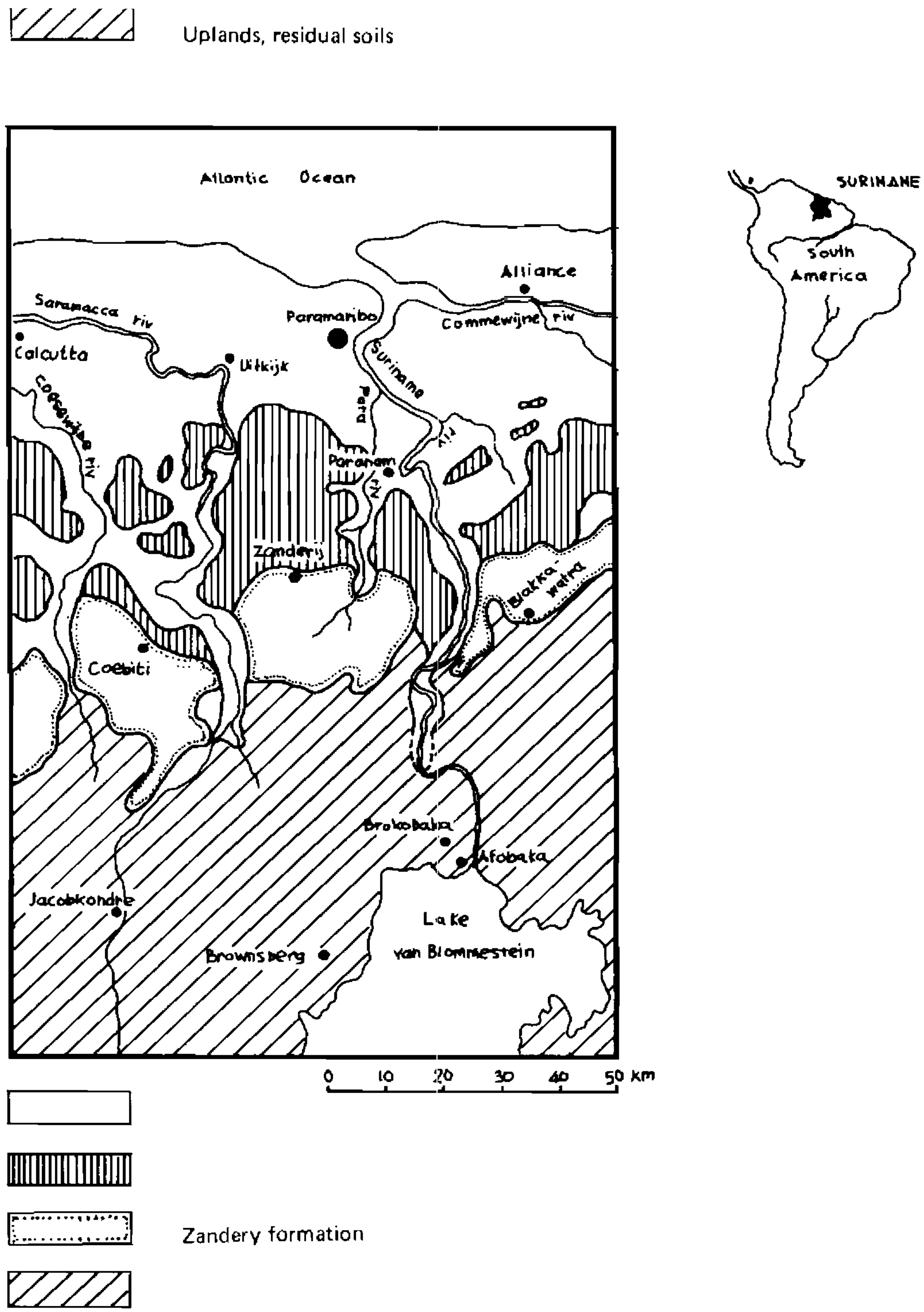

Fig.1. Schematic geomorphological map of part of Suriname (after Brinkman & Pons, 1968)

At Coebiti research on annual crops started in 1972 when a number of food crops were taken into observation. One of them was groundnut. The encouraging results obtained with this crop led to a more or less continuous series of field experiments during the following years. Various aspects were studied. This paper presents an account of the most important work that was carried out in the period 1972-1975.

GENERAL

Climate

Suriname has a tropical rainforest climate. In the period 1931-1960 the average monthly temperature at Paramaribo varied between 26.4 and 28.5°C, the relative humidity between 75 and 85% and the wind velocity between 1.1 and 1.7 m/sec. The annual rainfall distribution fluctuates strongly.

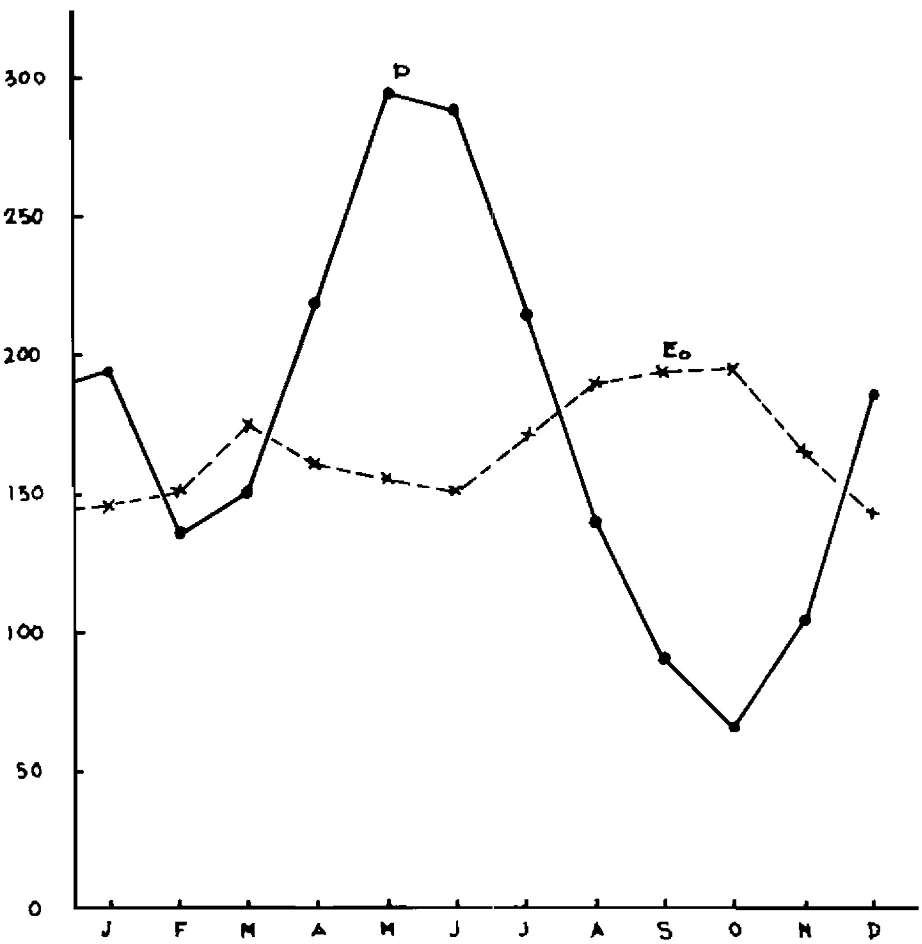

Fig.2. Average monthly precipitation (C) and free water evaporation (E_0) at Republiek, for the years 1906-1972 except 1912 and 1957.

Figure 2 depicts rainfall and free water evaporation data collected at Republiek, the nearest place to Coebiti (approx. 35 km) where rainfall has been measured over a long period. Four seasons are distinguished: the long rainy season, April-July; the long dry season, August-November; the short rainy season, December-January and the short dry season, February-March. The transitions from one season to another are not sharp and particularly the short rainy and short dry season set in very irregularly.

Soil

The experimental farm of Coebiti is located between the Saramacca and Coesewijne rivers (fig. 1). The texture of its topsoils, which belong to the oxisols, range from sand to sandy loam, the latter increasing with depth to sandy clay loam. With a few exceptions all experiments were carried out on sandy loam (see below). Table 1 presents some soil chemical data; the soil had not been cropped so far.

Table 1. Soil chemical data based on seven samples (0-20 cm) taken in May 1974

	average	range
Organic C, % (Walkley-Black)	1.17	0.80- 1.46
Total N, %	0.08	0.05- 0.10
C/N	15	14 -18
pH-KCl	4.1	3.9 - 4.3
pH-H_2O	4.7	4. 3- 5.0
CEC (pH=7), me/100 g soil	3.86	2.66- 4.69
exch. Ca, "	0.52	0.34- 0.84
exch. K "	0.06	0.04- 0.10
exch. Na, "	0.01	0.00- 0.04
P-Bray I, ppm P	1.8	0.7 - 4.4

The cation exchange capacity depends largely on soil organic matter, the kaolinitic clay being of minor importance. The amount of potentially available soil moisture (between pF 2.0 and pF 4.2) is low; the mean value for one metre depth is 145 mm (Janssen and Van der Weert, 1977).

Experimental

All experiments were carried out with the Spanish type cultivar Matjan. It was introduced from Java in 1950 and is the recommended cultivar in Suriname. Compared with other Spanish type cultivars it has large leaves and large seeds. Its growth duration is about 100 days. The gynophores do not easily rot through, which is an attractive characteristic in view of Suriname's climatic conditions. The cultivar is susceptible to *Cercospora* leaf spot and to leaf rust *(Puccinia arachidis).*

Unless otherwise stated, plant spacing was 60 x 15 cm. Fertilizer rates were 40 kg P_2O_5, as triple superphosphate, and 40 kg K_2O, as potassium sulphate, per hectare; in later experiments some nitrogen (urea) was applied at the rate of 10 kg/ha. The fertilizers were placed along the plant rows soon after emergence. The potassium was split, 15 kg being applied at emergence, the remainder three weeks later when plants started flowering. Weeding was done by hand. Apart from *Cercospora* leaf spot and leaf rust, diseases were absent. As to insects only *Stegasta basquella* sometimes caused damage to the foliage; the insect was controlled with a single application of trichlorphon. Occasional slugs were controlled with methicarb. All weights are expressed on the basis of 12% moisture content.

PRELIMINARY EXPERIMENTS

Towards the end of the long rainy season in 1972 small (480 m^2) observation plots were planted with various annual food crops one of which was groundnuts (Hoving, 1973). Plots were laid down on sand and on sandy loam. Half of each plot was limed; fertilizer was applied and *Rhizobium*-inoculated seed was used. The soil had never been cropped before: in 1969, immediately after clearing, kudzu *(Pueraria phaseoloides)* had been planted as a cover crop.

Of the annual crops planted groundnuts appeared most promising. The yield on sandy loam was double that obtained on sand. Liming had improved the yield both quantitatively and qualitatively: the percentage (w/w) of non-filled pods (pops) on the non-limed plots was nearly three times that on the limed ones.

Following these results a second series of trial plots was planted on both soil types during the short rainy season of that same year (Van Slobbe & Wienk, 1973). Again non-cropped soil was used. Three liming rates were included, i.e. 0, 2000 and 4000 kg $CaCO_3$/ha on sandy loam, and 0, 1500 and 3000 kg $CaCO_3$/ha on sand. The rates were compared in replicated randomized block experiments. Agricultural lime (Emkal) was used. Fertilizer rates were 40 kg N, 60 kg P_2O_5 and 80 kg (sand) or 60 kg (sandy loam) K_2O per ha.

Liming did not affect plant growth on either soil type, but on sandy loam plants grew better and a closed crop surface was obtained earlier than on sand, where the crop remained green much longer. Plants on the non-limed plots were still flowering when the trials were harvested, i.e. 111-118 days after planting (DAP).

Table 2. Effects of lime (Emkal) on yield and yield quality of groundnuts on sand and sandy loam

Soil type	liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg: total	number of pods per kg: pops
sand	0	499	53	1196	542
	1500	680	56	1134	304
	3000	723	60	1043	264
sandy loam	0	1556	71	876	149
	2000	2287	75	749	80
	4000	2316	75	726	83

Lime again showed a marked effect, the differences being largest between limed and non-limed plots (table 2). They yields on sand were very low, non-limed plots on sandy loam yielding more than twice as much as limed plots on sand. Apart from less pods per unit area, many of the pods produced were empty. Though lime considerably reduced the number of pops, on sand this number remained very high even at the highest liming rate. In view of these results it was decided not to continue with groundnuts on the sand.

LIMING

The preliminary experiments had clearly demonstrated that for groundnut production on the sandy loam soils of Coebiti liming is essential but that little was gained from increasing the amount of lime from 2 to 4 tons per hectare. However, the lime had been applied shortly before planting. A different effect might have been obtained if the groundnuts had been grown as the second crop following the liming. To obtain further information on liming effects, liming materials and liming rates some additional experiments were conducted.

The replicated trial mentioned in the previous chapter was replanted in 1973 at the end of the long rainy season to study the residual effects to the lime (Wienk & Van Muijlwijk, 1973). During the preceding months a leguminous cover crop *(Mucuna sp.)* had been planted to protect the soil from the heavy rain.

The incidence of *Cercospora* leaf spot now was higher and the disease appeared earlier than in the previous cycle of this trial; the crop was harvested 97 DAP. In spite of this the yields and the yield composition (table 3) were better than in the foregoing cycle. The results for the "non-limed" plots indicate that these plots could no longer be considered as such; apparently some calcium had been translocated from neighbouring, limed plots.

Table 3. Residual effects of liming (Emkal) on yield and yield composition of groundnuts on sandy loam

liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg: total	number of pods per kg: pops
0	2757	72	679	54
2000	2781	74	604	5
4000	3006	76	599	7

These findings show that the effect of lime on both the quantity and the quality of the groundnut crop was greater in the second cycle than when the crop was planted immediately upon liming.

The lime used in the previous experiments was Emkal, an agricultural lime imported from Europe. In further trial Aragonite (90% $CaCO_3$) a cheaper liming material of marine origin was used (Van Muijlwijk, 1974b). In a replicated experiment the rates 0, 450, 900 and 1350 kg $CaC0_3$/ha were compared. The soil had never been cropped before. The trial was planted in July 1973 at the end of the long rainy season.

Cercospora leaf spot occurred later in this experiment than in the second cycle of the liming trial reported above. No obvious differences in plant growth were observed. Flowering was noted to continue on the non-limed plots and to some extent also on the plots limed at the rate of 450 kg $CaC0_3$/ha. The experiment was harvested 103 DAP.

As to the yields and yield composition (table 4), , the results suggest that the optimum liming rate is somewhere between 450 and 900 kg $CaCO_3$/ha. Yields at the highest two rates differed little from those obtained on sandy loam in the preliminary experiment (table 2). The effect of calcium on yield composition was again clearly demonstrated.

Table 4. Effects of lime (Aragonite; 90% $CaCO_3$) on yield and yield composition

Liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
0	1115	49	1411	344	737
450	1939	67	871	213	187
900	2323	72	732	164	64
1350	2422	71	721	111	27

To study the residual effects of the Aragonite the experiment was replanted in December 1973 at the onset of the short rainy season (Van Muijlwijk, 1974b).

Growth was good during the first month after planting. *Cercospora* leaf spot appeared early in the growing season and affected the plants badly: two months after planting still no closed crop surface was obtained, which was in contrast to simultaneously planted trials where the previous season no groundnuts had been grown. As a result the trial suffered much from weed growth particularly in the plant rows. The experiment was harvested 104 DAP.

The results obtained (table 5) clearly demonstrate an effect of liming. Again the differences between the effects of 900 and 1350 kg $CaCO_3$ were small. The expected effect, i.e. higher yields in the second cycle following liming, was not realised, most likely because of the early attack from *Cercospora* leaf spot. Nevertheless, there appeared some after effect: the quality of the harvested crop was somewhat better now than in the previous cycle. Also here lime had been translocated to the "non-limed" plots: less pops were present per kilogramme pods now than in the first cycle of this trial.

Table 5. Effects of lime (Aragonite) on a second crop of groundnuts following the application of the lime

Liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
0	972	66	946	119	226
450	1050	73	750	138	86
900	1381	76	678	54	37
1350	1490	76	662	56	30

At harvesting composite soil samples were taken and analysed for Ca. The Ca-contents were 0.18, 0.30, 0.95 and 0.90 me/100 g soil for the 0, 450, 900 and 1350 kg $CaCO_3$ treatments, respectively.

In groundnut cultivation lime primarily serves to correct a calcium deficiency, fruit setting requiring the presence of calcium in the immediate vicinity of the pegs and the young pods. Application of the lime in 30 cm wide strips at a row spacing of 60 cm would mean a reduction of 50% lime as compared with the amount required in the case of broadcasting. Both methods of application were compared in a replicated field experiment using a rate of 1000 kg $CaCO_3$/ha effectively treated (Van Muijlwijk, 1974c). The soil had not been cropped before and the lime was applied shortly before planting. The trial was planted at the onset of short rainy season. *Cercospora* leaf spot did not appear until late in the growing season and caused very little damage.

As expected the results (table 6) did not reveal any differences between the two methods of application. Strip application was as effective as broadcasting the lime, the amount per unit area effectively limed being the same in both cases.

Given the non-cropped soil and the recent lime application the yield levels were reasonable.

Table 6. Effect of broadcasting (1000 kg $CaCO_3$/ha) versus strip application (500 kg $CaCO_3$/ha) of lime on yield and yield composition

Method of application	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
broadcast	2305	78	650	17	20
strip application	2331	78	618	24	4

Discussion and conclusions

Liming had a marked influence on the yield. As the vegetative growth was not affected the large differences in yield cannot be described to growth differences. The number of pods formed increased only slightly so that the higher yields were the result mainly of more seeds, i.e. better filled pods. If the calcium supply is inadequate many young pegs become necrotic and do not further develop; of the developed pods most are empty or only half filled thus reducing the quality of the harvested crop. These results demonstrate the well known phenomenon in groundnuts that calcium affects pod development rather than plant growth and thus is required most in the soil surrounding the developing pods (Brady, 1947).

An optimum liming rate was found between 450 and 900 kg $CaCO_3$ per hectare. With 900 kg $CaCO_3$ the amount of exchangeable calcium was raised from 0.18 to over 0.90 me per 100 g soil. This is well above the critical level reported by Colwell and Brady (1945) who found that below 0.60 me Ca per 100 g soil no good pod quality was obtained. No critical value was established, however, for the sandy loam soil at Coebiti. To be on the safe side a rate of 1000 kg/ha is therefore advised.

When applied to the preceding crop the effect of the lime was greater than when given at planting, the developing pods apparently reacting better to exchangeable calcium than to calcium carbonate. The solubility of the latter is low so it requires some time for the calcium ions to enter the exchange complex.

No experiments were conducted on the frequency of liming. In rotations this will depend on the calcium requirements of the other crops, on the rate of leaching and on the time lapse between two groundnut crops. With groundnuts every two years an annual application of 1000 kg $CaCO_3$/ha would seem adequate to maintain the calcium status of the soil.

Once the soil has been limed and lime applications are required only to maintain the calcium-status of the soil, strip application may be considered. As expected liming in strips so that half the amount of $CaCO_3$ is used, gave the same result as liming the entire area. In rotations of groundnuts with crops that demand less calcium, the lime can be more effectively applied in strips, concentrating it around the plant rows. With the tillage operations for the following crop the lime will be gradually distributed over the entire field.

Suriname has no limestone sources and agricultural lime needs to be imported. From an economic point of view nearby sources and cheap liming materials are required. Aragonite, which is used in Guyana's sugarcane industry, meets these criteria. Though it is much coarser than agricultural lime, it gave good results, suggesting that the coarseness does not play an important role. A direct comparison with agricultural lime was made but the experiment had to be abandoned, however.

The liming trials all suffered in various degrees from *Cercospora* leaf spot. On soil that had not been cropped before the symptoms were virtually absent until late in the season when the crop started ripening. When groundnuts followed groundnuts the leaf spots were observed as early as three weeks from planting. They rapidly spread and led to serious defoliation and yield reduction. In one instance a loss of 40% was estimated. From this it became obvious that *Cercospora* leaf spot was an important bottle-neck in the production of groundnuts at Coebiti.

PLANT DENSITY AND SPACING

The optimum plant density for Matjan under coastal conditions has been established at about 110,000 plants per hectare; a plant spacing of 30 x 30 cm was advised (Ter Horst, 1959) The small farmer usually plants at 30 x 15 cm (Veltkamp and Samlal, 1976). Most of them do not use Matjan, however.

For the time-being, awaiting experimental results, a density of 110,000 plants per hectare was chosen for the soils at Coebiti. The spacing was altered to 60 x 15 cm to allow agricultural equipment entering the field.

Spacing

In a replicated field experiment planted in 1973 towards the end of the long rainy season four plant spacings were compared, viz. 60 x 15, 75 x 12, 90 x 10 and the double row 70 x (20 x 20) cm (Van Muijlwijk, 1974a). With a view to the possible mechanization of cultural practices like weeding and ridging row distances smaller than 60 cm were not considered. The experiment was planted on a site where in the previous season maize and groundnuts had been grown; the soil had been limed. *Cercospora* leaf spot appeared early in the growing season. The disease was probably aggravated following heavy showers which caused lodging.

The yield (table 7) was highest for the 60 x 15 cm spacing; no statistical differences were found between the other three plant arrangements. The quality of the harvested pods was good, indicating that there was sufficient calcium in the soil. Weight per pod decreased as the plant distance in the row decreased but the differences were not statistically significant.

Table 7. Effect of plant spacing on yield and yield composition

Spacing (cm)	pod yield (kg/ha)	shelling %	number of pods per kg total	partly filled	pops
70 x (20 x 20)	2271	78	602	26	2
60 x 15	2750	78	605	17	4
75 x 12	2086	78	622	22	1
90 x 10	2263	78	631	33	1

Density

The effect of plant density on yield was investigated in a replicated experiment of the fan design (Bleasdale, 1967). Ten densities based on a square plant arrangement and ranging from 45,200 to 250,000 plants/ha were compared. Apart from the standard amounts of phosphatic and potassic fertilizer fritted trace elements (FTE-181) were applied at the rate of 140 kg/ha. The soil had been cropped before; lime had been applied in the previous season. The experiment was planted in 1973 at the beginning of the short rainy season (Van Muijlwijk, 1974c).

About three weeks after planting the first symptoms of *Cercospora* leaf spot were observed. The disease rapidly spread and after another three weeks had caused a considerable loss of leaves. No correlation between the amount of leaves lost and the plant density was established. Ten weeks from planting the entire experiment benomyl was sprayed.

Table 8. Effect of plant density on yield and shelling %
Experiment 1; *Cercospora* leaf spot not controlled

density (plants/ha)	pod yield g/plant	pod yield kg/ha	shelling %
45,200	39.4	1511	75
54,600	31.4	1713	77
65,800	29.7	1956	77
80,000	26.6	2128	78
96,200	23.0	2212	77
117,600	20.1	2360	78
140,800	17.1	2412	78
169,500	14.6	2480	78
208,300	11.8	2458	78
250,000	10.4	2592	78

From the results (table 8) it appears that the yield per unit area rapidly increased with density until 117,600 plants/ha. Above this number the yields further increased but at a much lower rate. A marked optimum was not found. Assuming that *Cercospora* leaf spot did not affect the results, a plant population of 110,000 per hectare seems acceptable.

Since an influence of *Cercospora* in the above experiment on the performance of the crop at high densities could not be excluded, the density trial was repeated in the following **short** rainy season (Van de Wall, 1975). The same densities were compared. *Cercospora* leaf spot was controlled with two-weekly applications of benomyl over a period of 10 weeks starting three weeks from planting.

Cercospora leaf spot did not become a problem and the crop retained its leaves until the ripening stage. In this experiment markedly higher yields were obtained than in the first one. Nevertheless, the same effects of plant density on yield were observed (fig. 3): pod yields rapidly increased with density until 117,600 plants/ha; above 140,800 plants/ha the yield increased very little if at all.

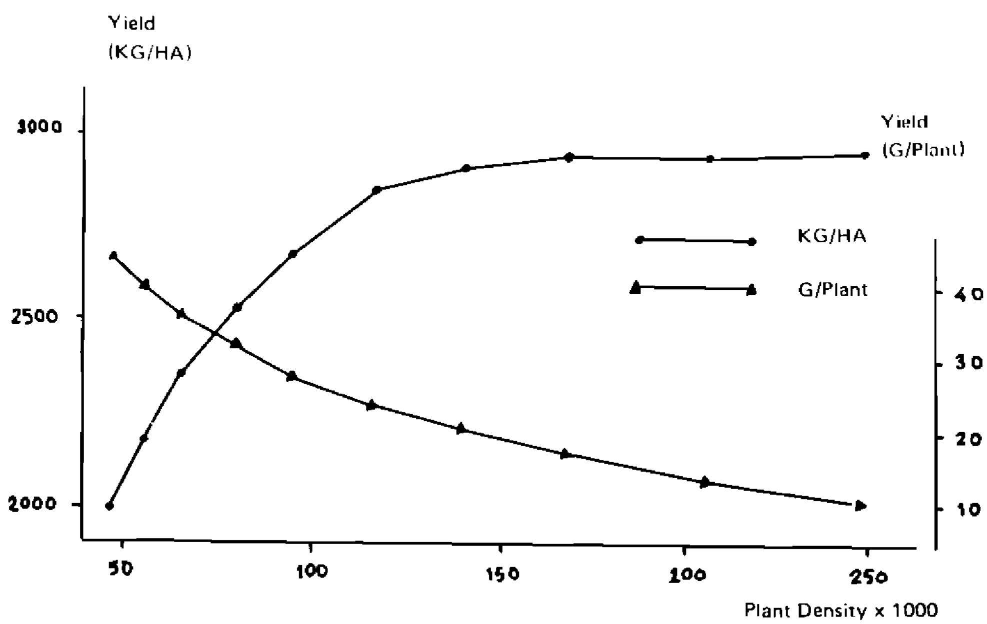

Fig.3. Pod yield per hectare and per plant for the cultivar Matjan, as affected by plant density.

Discussion and conclusions

The results of the density trials closely agree with those obtained by Ter Horst (1959) under coastal conditions. At densities higher than 110,000 plants per hectare yields per unit area still increased but the rate of increase was much less than at lower densities. Ter Horst (l.c.) considered the differences too small to offset the higher costs of the extra seed, the planting, the harvesting and the stripping at higher densities. It should be added that the small farmer does everything manually. On the other hand, even when completely mechanized the relatively small yield increases seem of little practical interest. A density of 110,000 plants per hectare as under coastal conditions can also be used for the sandy loam soils at Coebiti.

When *Cercospora* leaf spot was controlled the yield level was about 20% higher than when no measures had been taken. Plant density appeared not to have affected this relative difference. Whether the level of infection was influenced or not cannot be concluded; no disease scores were taken.

The absence of an effect on yield and perhaps also on disease incidence could well be explained by the experimental design used. The different densities being represented by individual arcs in one plot, the disease may have easily spread from one arc to another. A randomized block design may have presented a completely different picture and revealed such a relation much better than the fan design.

Generally plant populations of 160,000 to 180,000 per hectare are advised for groundnut cultivars of the Spanish type (Gillier and Silvestre, 1969). The comparatively low optimum for the cultivar Matjan probably must be ascribed to its relatively large leaves and its open growth habit which is characterized by long upright branches.

The spacing trial clearly showed that an arrangement of 60 x 15 cm was superior to wider row spacings. As observed by Fung Kon Sang (1966) this might be explained by the closer plant distances in the row which favourably influenced the development of *Cercospora* leaf spot through a better micro-climate. The performance of the double-row arrangement too can be explained by this, the micro-climate in the two closely planted rows being different from widely spaced single rows with the same plant distance. Unfortunately, as no disease scores were taken, a definite conclusion cannot be drawn. The experiment needs to be repeated and include disease control measures to avoid any interaction.

CERCOSPORA LEAF SPOT CONTROL

The cultivar Matjan proved very susceptible to *Cercospora* leaf spot. Yield losses were not actually assessed but preliminary estimates indicated that the yield could be reduced by some 40% if the crop was preceded by groundnuts (Van Muijlwijk, 1974b).

In a replicated field experiment planted towards the end of the long rainy season of 1974, the effects of (a) *Cercospora* leaf spot control, (b) removing the weeds from the plant rows, and (c) fertilizing on yield were studied (Bink, 1975). A 2^3 factorial design was used. The experiment was planted on a site where in the previous season groundnuts had been grown.

Cercospora leaf spot was controlled with benomyl applied four times at 2-weekly intervals starting three weeks from planting. The experiment was weeded between the plant rows 10 and 34 DAP. The second time also the plant rows were weeded where appropriate. The fertilized plots received 10 kg N (urea), 40 kg P_2O_5 (triple superphosphate), 40 kg K_2O (potassium sulphate) and 140 kg fritted trace elements (FTE-181) per hectare.

Five weeks from planting a few leaf spots were recorded in the non-sprayed plots. The disease gradually spread and two weeks later clear differences were observed between the sprayed and the non-sprayed treatments. Nine weeks from planting the plants in the non-sprayed plots had lost many leaves; in the sprayed plots the older leaves were still green. Very small differences, if any, in leaf spot incidence were noticed between the weeded and the non-weeded plots or between the fertilized and the non-fertilized ones.

Weed growth was not excessive. Fertilizing did not affect the amount of weeds as determined by their dry weight at harvesting. Leaf spot control affected the amount of weeds markedly.

About 75% of the total amount of weeds was present on the non-sprayed plots, the reduced soil cover being completely responsible for this effect. The removal of weeds from the plant rows 34 DAP had reduced the amount of weeds present at harvesting by 50%. Fertilizing, weeding and spraying together reduced the weed growth to one sixth of that on the combined non-fertilized, non-weeded and non-sprayed plots.

Cercospora leaf spot control affected the yield more than weeding or fertilizing (table 9); the effect as opposed to not spraying was 36%. Weeding had not improved the yields whereas the effect of fertilizing was only 9%. No significant interactions were found.

Table 9. The effects of *Cercospora* leaf spot control, weeding and fertilizing on yield (kg/ha)

Cercospora leaf spot	fertilized		not fertilized		
	weeded	not weeded	weeded	not weeded	mean
controlled	3596	3220	3036	3319	3293
not controlled	2187	2305	1980	1916	2097
mean	2827		2563		
	weeded 2700				
	not weeded 2690				

The differences in yield between the sprayed, fertilized and weeded crop and the crop where none of these measures had been taken, is spectacular. The reduction by not taking the measures was 47% of which four fifth was accounted for by leaving out the spraying and one fifth by not fertilizing. As to the quality of the crop the spraying with benomyl had resulted in halving the number of germinated seeds. Also, at harvesting less pods remained in the soil than on the non-sprayed plots.

Since the losses from *Cercospora* leaf spot can be high, some measure of control seems essential. At Coebiti the systemic fungicide benomyl had proved very successful in controlling *Cercospora*. However, the protracted use of benomyl increases the danger of inducing resistance in the pathogen (Clark et al., 1974). Moreover, at Coebiti the impression had been obtained that the use of benomyl increased the incidence of leaf rust *(Puccinia arachidis)*. In view of this an experiment was conducted in which the effects of benomyl (Benlate) were compared with those of three non-systemic fungicides, viz. propineb (Antracol), copper oxychloride (Cupravit) and fentin acetate (Brestan) (Van de Weg, 1975). The experiment was planted in the short rainy season, January 1975 on a site where the previous season also groundnuts had been grown but where no disease control measures had been taken. Each fungicide was applied at two frequencies. Benomyl was applied 2- and 3-weekly, the other fungicides weekly and 3-weekly. The concentrations used were Benlate 1 g/litre, Antracol 3 g/litre, Cupravit 5 g/litre and Brestan 2 g/litre.

Cercospora leaf spot was already present at three weeks from planting when a start was made with the fungicide treatments. Spraying was continued until about two weeks before harvesting, 100 DAP. The incidence of *Cercospora* leaf spot and leaf rust was recorded weekly (index 0-5; 0 = no symptoms). The sum of the weekly scores is presented in table 10.

Table 10. Effect of fungicides and frequency of application on yield, fresh weight of stems and leaves at harvesting, and on the incidence of *Cercospora* leaf spot and leaf rust

Fungicide	frequency of application	pod yield (kg/ha)	fresh weight stems and leaves (kg/plot)	incidence *Cercospora*	incidence leaf rust
benomyl	2-weekly	2826	14.8	3.8	2.3
	3-weekly	2569	11.8	10.4	9.3
propineb	weekly	2728	12.8	42.0	0.0
	3-weekly	2111	10.5	59.7	2.0
copper oxy-chloride	weekly	2830	15.2	20.3	0.0
	3-weekly	2546	13.5	42.3	1.0
fentin acetate	weekly	2917	15.6	20.7	0.7
	3-weekly	2870	13.8	36.3	0.7

Benomyl appeared to control *Cercospora* best. Leaf rust incidence was highest in the plots sprayed 3-weekly: at harvesting no green leaves were left. This effect is clearly demonstrated by the fresh weights of the above-ground parts at harvesting (table 10).

Propineb provided least control of *Cercospora*. The disease rapidly spread and resulted in leaf loss, particularly at the lowest frequency of application. A few leaves with rust symptoms were observed but at the lowest frequency only.

Fentin acetate appeared to be phytotoxic during the first seven to eight weeks, particularly at weekly application. Later these symptoms disappeared completely. At first the level of *Cercospora* infection was fairly high (up to 40 spots per plant) and little difference was observed between the two frequencies of application. Later, weekly spraying provided a reasonable control. At 3-weekly applications the disease was not controlled adequately and resulted in extra leaf loss. Very little rust was observed.

Copper oxychloride controlled *Cercospora* in much the same way as fentin acetate; weekly application being better than 3-weekly sprayings particularly at a later growth stage of the crop. Also with this fungicide very little rust was observed.

The yield differences were not very large (table 10). No statistical differences were found between the fungicide treatments. Within fungicides, generally the lowest frequency of application resulted in the lowest yield but the difference was only significant in the case of propineb.

Discussion and conclusions

The results of the fertilizing x disease control x weeding experiment confirmed that the yield of the cultivar Matjan can be considerably reduced if no disease control measures are taken. When occurring early in the growing season *Cercospora* leaf spot causes serious defoliation which in turn leads to increased weed growth. Since weeding had no effect on the yield the reduced yield caused by *Cercospora* must be entirely ascribed to the loss of photosynthetic leaf area. On the other hand, the presence of weeds can lead to pod loss at harvesting, pods becoming entangled in the weeds' roots, especially if the weeds occur in the plant rows. In the present experiment the soil was carefully searched for detached pods which were included in the harvest.

Excessive weed growth, particularly of broad-leaved species, could also influence the crop's micro-climate and so favour the development of *Cercospora* leaf spot. Such an effect was not observed, probably because weeds consisted mainly of grasses and were not a real problem.

Cercospora leaf spot can also have a qualitative effect on the yield. The groundnut crop ripens earlier and more uneven than when the disease is absent. If the ripening of such a crop coincides with a wet spell many seeds may germinate, as was the case in this experiment. The fungicide treatment reduced the number of germinated seeds by half. Germinated seeds are vulnerable to infection with *Aspergillus flavus* thus favouring the development of aflatoxins.

Benomyl effectively controlled *Cercospora*. But when applied 3-weekly this fungicide led to a severe attack of leaf rust. Also from the literature (Harrison, 1973) it is known that benomyl does not control *Puccinia arachidis*. Probably it kills the pathogens that compete with this fungus so that the rust can develop more easily and more agressively.

The yields obtained with fentin acetate and copper oxychloride differed little from the one when benomyl was used. Only propineb, when applied at 3-weekly intervals, gave significantly lower yields. As expected the higher frequency of application gave for each fungicide the best results. The incidence of *Puccinia arachidis* was negligeable for all three non-systemic fungicides.

Fentin acetate has also been recommended by Ter Horst (1961). He used the same concentration but at weekly intervals. In view of the phytotoxicity symptoms observed at this frequency of application a 2-weekly application seems more appropriate. The chemical is cheaper than benomyl. A disadvantage is that at small quantities fentin acetate is much more toxic than other fungicides.

Benomyl and related chemicals are known to be able to cause resistance in *Cercospora*. This phenomenon has also been reported for *Cercospora arachidicola* and *C. personata* (Clark et al., 1974), the two causative organisms of *Cercospora* leaf spot in groundnuts. Genetic changes that may lead to resistance require sexual propagation of the fungus. The perfect stages of *Cercospora* are not likely to occur in the tropics so that the chances that in Suriname resistance to benomyl develops probably are much smaller than where the perfect stages are known to exist. The possibility cannot be completely ruled out, however. Some precaution may be necessary. Resistant strains are known to spread rapidly when benomyl is used repeatedly and exclusively. Alternating use of fungicides with different action spectra seems therefore advisable.

From the results obtained it appears that apart from benomyl chemicals like fentin acetate and copper oxychloride can be used to effectively control *Cercospora* leaf spot.

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NAME OF PAPER: Groundnut Experiments at Coebiti in the period 1972–1975: a summary of results.
(J.F. Wienk)

Question by: A . Wahab
Country: Jamaica

QUESTION: It appears that higher densities produce higher yields. In Jamaica on newly terraced hillside soils (25^o slope) we (Wahab and Campbell) compared peanut yields (Spanish Var.) at 10, 50, 100 kg/ha Nitrogen as urea against a standard application of P_2O_5 (300 kg/ha) K_2O (150 kg/ha). Plant density was 500.000 plants/ha 40 cm rows with 1 plant per 5 cm row. First trial indicated no significant difference between N levels.
Averaging 4.3. tons/ha of shelled peanuts. May be you ought to try higher densities vs. var. trials?

ANSWER: The results from the density trials show that yields level off at fairly low densities. This could indeed be a varietal characteristic, as I think it is. It could also suggest that mineral nutrition was a limiting factor. As I explained we used standard fertilizer rates throughout the various trials. These were rather low so that greater amounts of fertilizer could alter the relation density-yield. This will need further systematic research. On the other hand we did some experiments in which we applied higher rates of fertilizer. No response was obtained. We also took leaf samples for chemical analysis. The mineral contents when compared with critical values as reported in the literature, did not suggest that mineral nutrition was sub-optimal. I am convinced that there must be other cultivars with a higher yield potential than the cultivar Matjan. In fact we do have some experimental lines which were selected from an unselected family we received from Nigeria some years ago. They are less susceptible to *Cercospora* and at a density of 110.000 plants/ha produced more than Matjan but did not provide a closed canopy so that the optimum density is likely to be much higher with a correspondingly higher yield.

Question by: B. Lauckner
Country: Barbados

QUESTION: The tables in the paper give many statistics, but little indication of whether there are any significant differences between these statistics. Only ocassionally does the text indicate whether differences are significant or due to experimental error. Why were (at least) standard errors not quoted?

ANSWER: I would say that this is criticism rather than a question. But let me make myself clear: I consider it valid criticism. However, in my paper I did not pay much attention to the statistical aspects because, as indicated in the title, it is a summary of results so I left it out. Of course if the meeting feels that it is a serious ommission I am quite prepared to add what Mr. Lauckner calls at least the standard errors. Whether differences are statistically significant very much depends on the probability level used. Mostly 5% is taken. Some are satisfied with 10%, others want 1%. Furthermore, what test is used to define significance. Student, Gabriel-Scheffé, Duncan? This is personal. Therefore I prefer to give the basic information of standard error, general mean of replications so that everybody for himself can try and work out the significance the way he wants and the probability level he prefers.