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Date of planting and variety of maize are two of the most important factors for increasing maize production in W. Africa. Although temperate hybrid maize under high fertilizer treatments produced 60% greater yields than native varieties under the same conditions, yields and other characteristics of the temperate hybrids were not altogether satisfactory. The search for varieties that are more responsive to fertilizers and better adapted to the conditions of West Africa must be continued.

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MAIZE AS A SECOND CROP FOR THE UPLANDS OF SIERRA LEONE, WEST AFRICA

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The objective of this bulletin, published under the theme: "Food and Fiber Production - - A World-Wide Concern", is the dissemination of research results which may contribute to the agricultural development of tropical countries throughout the world.

ABSTRACT

Maize planted between August 15 and September 1 on alluvial soils in Sierra Leone, W. Africa, produced higher grain yields than earlier or later planting dates. Stover yields were highest for planting from May 15 through June 15.

Grain and stover yields responded to increasing levels of fertilization and varied according to varieties. Planting densities from 40,000-70,000 plants/ha did not affect grain yields, but influenced stover production.

Date of planting and variety of maize are two of the most important factors for increasing maize production in W. Africa. Although temperate hybrid maize under high fertilizer treatments produced 60% greater yields than native varieties under the same conditions, yields and other characteristics of the temperate hybrids were not altogether satisfactory. The search for varieties that are more responsive to fertilizers and better adapted to the conditions of West Africa must be continued.

Maize as a Second Crop

During the last decade, poultry and swine production has increased and with it the demand for maize. In this period, 47% of the farmers were growing maize in mixed stands with upland rice (4). The quality of maize was poor and the yields were low, estimated at only 20 bus/hectare based on full hectare stands (3). On this basis, 19,000 hectares of maize were grown yearly on less than 2% of the total cultivated land. The people ate most of it as whole grain, only 1% was sold as feed to the poultry industry. (15). Prices of shelled maize at the time averaged $68.00 per ton in the Freetown market.

On several field experiments at Njala, unrelated to maize culture, we experienced yields in excess of 4000kg/ha of shelled corn using synthetic varieties under supplemental irrigation in the dry season. These optimistic results led us to speculate whether maize planted close to the end of the wet season might mature without undue moisture stress before the dry season progressed and soil moisture was depleted. If this system proves economically feasible maize could be introduced as a crop which could change the traditional pattern of one crop per season.

This paper describes a series of experiments that tested the effects of planting date, density of stand, fertilizer treatment, and variety on maize yields growing on uplands river terrace soils of the humid tropics of Sierra Leone.

Conclusion, based on the results of planting date experiment must be considered demonstrational only and not interpreted as statistically valid for two reasons: one, the data represents the work of a single year, and two, the lack of funds prohibited the replication of planting dates. The results of the other parameters viz: density of stand, fertilizer treatments, and varieties based on a single year's results are statistically valid.

Before this system can function however, there are serious problems of land cleaning after harvest of the first crop and depletion of nutrient soil reserves that must be overcome. Cognizant of these problems, we hope that the encouraging results of this study will prompt further research on maize as a second crop for those people living on the relatively infertile upland of Sierra Leone.

SITE, MATERIALS AND METHODS

Sierra Leone is situated on the coast of W. Africa, between 7° and 10° N. latitude. The country has a distinct wet and dry season, May-November and December-April, respectively. The rainfall at Njala U. C. averages 277 cm per year, of which 240 cm falls during the wet season. The average maximum daily temperature fluctuates between 27.1C and 35.0C between the dry and wet seasons. (Fig. 1).

The maize trials described here were situated on alluvial soils bordering the River Taia on land which was cleared that year (without burning) of 25-year secondary forest. The dominate cover after clearing and before the experimental sites were established was Pueraria phaseoloides and Centrosema pubescens. A cursory fertility map of the area was prepared using yield of the cover as criteria. Characteristics of the soil (Nyawama Series) are tabulated in Table 1.

Date of Planting Trial:

This trial involved a complete randomization of 5 varieties replicated 4 times within each of 10 planting dates, beginning May 15, 1968, every 15 days, to and including October 1, 1968. The plots were brushed several days before planting, the material removed from the plots, and the soil plowed with native hoes to 16 cm depth. The area was then raked and staked.

Maize was seeded in rows spaced 90 cm apart (not ridged) and 30 cm within the row at rate of 40,000 plants/ha. At planting, all plots were fertilized with 560 kg/ha of basic slag, 336 kg/ha (20%) super phosphate, 224 kg/ha potassium sulphate and 224 kg/ha of ammonium sulphate. An additional 224 kg/ha of ammonium sulphate was sidedressed 6 weeks after emergence. The ammonium sulphate followed two days after application of basic slag to reduce the release of NH^3 when both compounds are mixed during application.

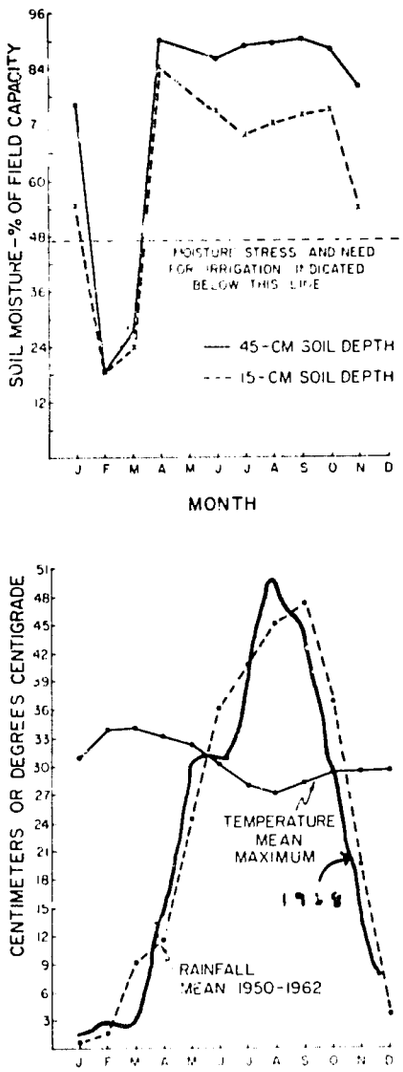

Figure 1. Soil moisture, precipitation, and temperature data at Njala University College, Sierra Leone, West Africa.

Table 1. Physical and chemical properties of Nyawama alluvial soil 3-18 cm depth, Sierra Leone, W. Africa.

Parameter	Identification
Soil Series	Nyawama sandy clay loam
Classification	Typic Haplustox
Particle size distribution 2mm in %:	
Gravel	0
Sand	62
Silt	15
Clay	23
Exchangeable cations, m.e. 100 g soil:	
Calcium	0.08
Magnesium	0.10
Potassium	0.02
Sodium	0.05
Aluminum	2.00
Cation exchange capacity m.e./100 g soil	6.7
Base saturation in %:	3.7
pH, 1:1 in water:	4.5
Organic C in %:	1.26
Clay (in order of abundance)	1. Kaolinite 2. Gibbsite 3. Chlorite

* Data from Soil Survey Report, J. C. Dykerman & H, Breteter, Njala, U. C.

The maize ears at harvest averaged 18-20% moisture, were shelled, dried to 14% moisture, and weighed. Stover was cut at ground level, dried and weighed.

Hybrid maize (Funk Hybrids — G-901, G-4949, G-5858, G-5945) and native maize were used. The hybrid maize are temperate climate varieties averaging 150 days to maturity in the temperate zones. The native maize, indigenous to Sierra Leone, varied from 120-140 days maturity period.

Planting Density, Variety and Fertility Trials:

Concomitantly with the date of planting trials, this experiment tested 4 varieties of hybrid maize (Funk Hybrids — G-901, G-4949, G-5858, G-5945) on the Nyawama alluvial soils at three levels of plant density (40,000, 50,000 and 70,000 plants/ha) under three levels of fertilization; high, medium, low, in a randomized split-plot design replicated 4 times. Prior to planting, the area was brushed with cutlasses and the material plowed into the soil with native hoes. The area was raked and large pedons broken by hand.

The maize was planted on May 21, 1968, in 90 cm rows (not ridged) and the distance between plants within the rows calculated to the required planting density.

High fertilization consisted of 224 kg/ha of ammonium sulphate at planting,, 112 kg/ha 3 weeks after emergence, and 112 kg ha at tasseling. Also 600 kg/ha of basic slag, 224 kg/ha potassium sulphate, 60 kg/ha magnesium sulphate and a micronutrient mix of Zn. Cu, Fe, B, Mo, and Mn in sand were applied.

The medium fertilizer rate consisted of 112 kg/ha ammonium sulphate at planting and 112 kg applied 3 weeks after emergence, 300 kg/ha basic slag, 112 kg/ha potassium sulphate, 30 kg/ha magnesium sulphate and a micronutrient mix.

The low level of fertilization consisted of 112 kg/ha ammonium sulphate at planting, 146 kg/ha basic slag, 55 kg/ha potassium sulphate, and 15 kg/ha magnesium sulphate.

The maize was harvested when grain moisture reached 18-20%. The grain was shelled, dried to 14% moisture, and weighed. Stover was cut at ground level and weighed in the field.

Soil moisture sensors were buried at random throughout the site at 10, 15, 30 and 45 cm depths each replicated 10 times. Readings were taken every third day and at the end of each rainy day throughout the year. (Fig. 1)

RESULTS AND DISCUSSION

The maize yields tabulated in Tables 2 and 3 clearly indicate that planting dates for highest grain yields for all varieties fell between August 15th and September 1st. During this period variety G-901 averaged 3,300 kg of grain per hectare which was higher than other varieties and was 60% greater in yield than the native variety. Maize planted after June 1st, but before June 15th, the traditional time of planting, yielded 50% less grain for all varieties (48% less for the native variety) than the maximum production achieved between the August and September planting dates (Table 3).

The low yields experienced between May and August plantings probably could be attributed to the excessive cloudiness resulting a a diminution of direct sunlight with a corresponding reduction in seed production. Coupled with this was a loss of grain as a consequence of cob rot and rust which prevailed at maturity during the wet months of August, September and early October, when rains were heaviest, averaging 43 cm per month during this three month period.

The heights of maize at harvest, as a response to planting dates, are depicted in Fig. 2. Diminution in height became

Table 2. Effect of planting dates on yields of grain and stover for 5 varieties of maize.

Planting Date	Variety				
	G-901	G-4949	G-5858	G-5945	Native
	Grain[1] in kilograms/ha				
15 May	1219	1155	706	840	706
1 June	1605	770	449	706	1091
15 June	1540	706	384	706	710
1 July	574	257	192	385	395
51 July	706	385	102	449	321
1 August	1027	321	257	514	257
15 August	**3338**[2]	**1990**	**1155**	**1435**	**1402**
1 Sept.	**3081**	1412	**1091**	**1809**	624
15 Sept.	1476	855	835	706	122
1 Oct.	1926	1219	835	1412	102
	Stover[1] in kilograms/ha				
15 May	4622	**4174**	2504	2247	**6805**
1 June	**4943**	1861	642	1284	2311
15 June	**5906**	2889	**2247**	**2758**	3017
1 July	2182	1348	1435	1412	1435
15 July	2200	1733	1540	1476	1412
1 Aug.	2439	1089	1091	1155	1098
15 Aug	—[3]	—	—	—	—
1 Sept.	—	—	—	—	—
15 Sept.	2500	1300	1285	1476	—
1 Oct.	3210	2054	1285	2311	—

S. E. 0.102

(1) Average of 4 replicates per variety.

(2) The values in bold print are highest for respective varieties and in the same colum are not significantly different at the 0.05 level.

(3) Funds unavailable for stover harvest.

Table 3. Mean grain yield and maturation period for all maize varieties as a function of planting dates.

Planting Date	Mean Grain Yield Kilograms/ha		Average No. of Days to Maturity (Hybrid Values Only)
15 May	942	d	118
1 June	936	d	106
15 June	850	e	102
1 July	358	g	109
15 July	413	fg	112
1 Aug.	485	f	103
15 Aug.	1891	a	112
1 Sept.	1589	b	120
15 Sept.	803	e	126
1 Oct.	1107	c	124

Values with the same letters not significantly different at the 0.05 level.

evident after the May 15th planting, and most severe at the July 1st planting when the maize was subjected to increased cloudiness, reduction of sunlight, and lower day temperatures as rainfall increased (Fig. 1). After the August plantings, the young maize began to achieve greater heights as the rains diminished, hours of direct sunlight and temperature increased, and soil moisture remained adequate (Fig. 1).

Maize planted after September 15th up to and including October 1st also resulted in 50% less grain yield than the maximum. Although the sunlight intensity was higher than the early plantings, the paucity of rainfall coupled with higher temperatures was responsible for the low yields. Data in Fig. 1 indicated that soil moisture stress in the root-

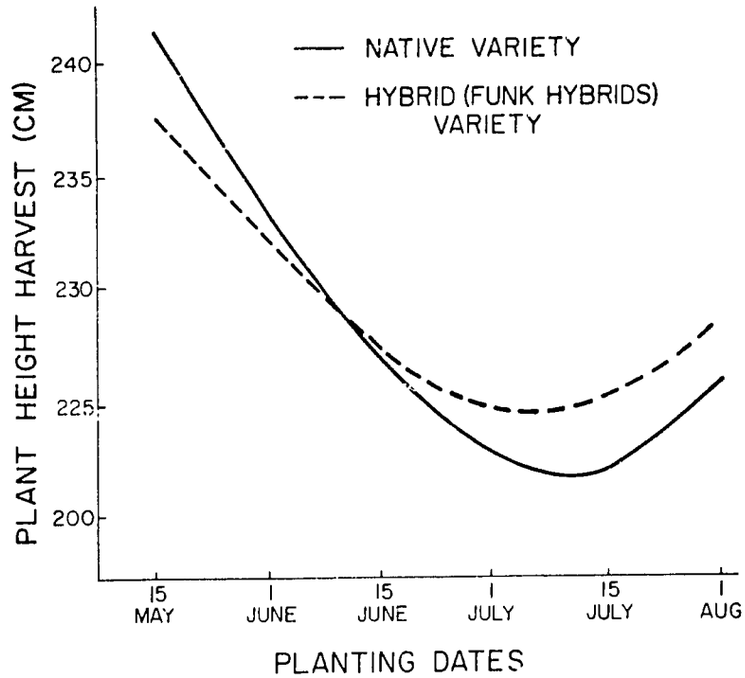

Figure 2. Effect of planting dates on heights of maize at harvest.

ing zone (10 cm) was beginning to become increasingly severe in early December. At this time, maize planted September 1st was approaching its maximum requirements for moisture.

Stover production was maximum for all varieties for planting dates between May 15th and June 15th. The native variety produced the highest yields averaging 6,000 kg/ha when planted on May 15th. The most severe drop in stover production per variety occurred in maize planted after July 1st (Table 2). Apparently the increasing number of cool, cloudy days reduced the amount of direct sunshine to the

very young plants, resulting in a reduction of carbohydrate production during that period of rapid growth.

It can be concluded that planting dates for maximum grain production of maize, of the varieties used in this trial, ranged between the 15th of August and the 1st of September. For the highest stover production, the optimum planting dates lie between May 15th and June 15th included. For the native variety, the May 15th planting resulted in the highest stover yield among the varieties tested.

The severe drop in grain yields for all varieties, when planted after September 1st, must be noted if maize should be considered as a second crop after rice.

Planting Density, Variety, and Fertilizer Trials of Maize:

The results (Table 4) show that the yield of grain for all varieties varied significantly between fertilizer treatments and varieties, but not to planting densities between 40,000 and 70,000 plants/ha. There were significant interactions for grain yield between variety density and variety/fertilizer which suggests the important influence variety assumes in the production of maize (grain).

The grain yields for all varieties under all density levels averaged 2278, 2062, 1751, kilograms/hectare under high, medium, and low fertilization levels respectively (Table 5). Variety G-901 yielded the highest grain production, averaging 2550 kilograms of grain per hectare at the high fertilization level and 1835 kilograms/ha at the low fertilization rate; a yield increase of 39 percent showing a better response to fertilizer than the other varieties.

Stover yields were dependent on all three parameters particularly variety. No interactions were detected between any parameter for stover yield (Table 4). A density of 70,000 plants/ha produced on the average for all varieties and fertilizer treatments, 4475 kilograms ha of stover (Table 5). This was significantly higher than the stover yields of maize at planting densities of 55,000 and 40,000 plants/ha, which averaged 3591 and 3750 kilograms of field dried stover/ha, respectively.

Table 4. Analysis of variance of maize response to planting density, variety, and fertilizer.

Source of variation	Degrees of Freedom	F Value
GRAIN		
Main effect of A-density	2	0.072
Main effect of B-fertilizer	2	20.551**
Main effect of C-variety	3	12.233**
AXB	4	0.283
AXC	6	2.487*
BXC	6	3.013*
AXBXC	12	0.768
STOVER		
Main effect of A	2	10.260*
Main effect of B	2	7.235*
Main effect of C	3	48.406**
A x B	4	2.605
A x C	6	1.967
B x C	6	1.341
A x B x C	12	0.557

** significant at the 0.01 level

* significant at the 0.05 level

Table 5. Yields[1] of grain and stover under various density and fertilization levels of the respective varieties.

Planting Density (Plants/ha)	Fertilization Level	Variety G-901	G-4949	G-5858	G-5945
		Grain Yield-Kilograms/ha			
40,000	High	2510	2500	1756	2220
	Medium	2434	2014	1606	2114
	Low	2080	1740	1630	1464
55,000	High	2504	2450	1856	2140
	Medium	2070	1950	2040	2420
	Low	1910	1904	1620	1504
70,000	High	2634	2724	1816	2222
	Medium	1800	2360	1720	2210
	Low	1516	2250	1690	1700
		Stover Yields-Kilograms/ha			
40,000	High	6320	4120	3096	2986
	Medium	5360	3340	2900	3160
	Low	5720	2776	3025	2716
55,000	High	5980	4260	3490	3260
	Medium	5656	2890	2880	3314
	Low	4414	2876	2130	1940
70,000	High	7280	4200	4420	4670
	Medium	4254	4046	3614	3464
	Low	4834	4700	4644	3580

(1) Average of four replicates each.

Maize as a Second Crop

As in the grain production, variety G-901 produced the highest stover yields averaging 6527 kilograms of stover per hectare at the high fertilization rate under all planting densities.

It is important to note an apparent discrepancy that grain and stover production under low fertilization levels averaged higher for all varieties in the May planting than the same varieties planted in May under optimum fertilization levels in the date-of-planting trials discussed previously. Both experiments were situated in the same 10-acre tract, but in sites separated by 50 meters of border zone. The difference in yields reflects primarily the soil fertility variabilities of adjacent sites in newly cleared tropical soils.

The results of both experiments show that maize planted between August 15th and September 1st produced the highest grain yields, provided other cultural factors are favorable, while stover production was highest for early planting and densities between 40,000 and 70,000 plants/ha. It appears therefore that the two most influential factors for increasing maize production are date-of-planting and the use of varieties which will respond to high levels of fertilizer. Although Funk hybrids (G-901 and G-4949) performed better than the other, including the native variety, under conditions of these trials, temperate climate varieties must be tested further with those developed under tropical conditions to ascertain the most suitable ones for upland soils in Sierra Leone.

Literature Cited

1. Boston, W. — Poultry and Swine Production in Sierra Leone, Research Report. Njala University College, Office of Research Coordinator Office. 1969.

2. Inman, L. — Terminal Report, Agriculture in the Tropics. University of Illinois, Department of Agronomy. 1969.

3. Miracle, M. P. — Maize in Tropical Africa. University of Wisconsin Press. 1966.

4. Mitra, A. K. — Land Use and Resources Utilization in Sierra Leone. Report of IDAS. Project Team, Freetown, Sierra Leone, Africa. 1968.

5. Mutti, R. J. Marketing Stable Food Crops in Sierra Leone. University of Illinois, Department of Agricultural Economics. 1968.