EFFECTS OF PLANT POPULATION AND FERTILIZERS ON YIELD AND YIELD COMPONENTS OF CASSAVA IN THE FOREST ZONE OF GHANA

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SUMMARY

Under the soil moisture conditions of experiments carried out at Kumasi, Ghana, comparing cassava yields at five densities over the range 9259 to 74,074 per hectare, 18,500 plants per hectare increased yields; plant densities higher than this resulted in a drop in yield. Water supply was probably limiting yield since the crop did not respond to fertilizers even at high density except by increased top growth. Yield per plant, average tuber weight, weight of tops, average number of stems and tubers/plant were not affected by fertilizers, but they all decreased with an increase in plant population beyond 18,500.

RESUME

Des essais menés en conditions d'humidité du sol á Kumasi, Ghana, comparant des rendements du manioc de cinq densités partant de 9259 à 74.074 a l'hectare, ont révélé que 18.500 plants à l'hectare ont accru le rendement; des densités plus élevées entraînent une baisse de rendement. L'approvisionnement en eau limitait probablement le rendement dans la mesure où la plante en répondait pas aux engrais, méme quand la densité est élevée, sauf au niveau de la croissance de la tige. Les engrais n'ont pas eu d'effet sur le rendement par plant, le poids moyen des tubercules, le poids des tiges, le nombre moyen des tiges et tubercules par plant, mais il y a eu baisse à tous les niveaux lorsque la densité dépassait 18.500.

RESUMEN

Bajo las condiciones de humedad del suelo en experimentos conducidos en Kumasi, Ghana, los rendimientos de yuca aumentaron hasta densidades de siembra de 18,500 plantas por hectárea, dentro del rango de comparación que fué de 9,259 hasta 74,074 plantas por hectárea; densidades mayores a 18,500 redujeron el rendimiento. El abastecimiento de agua limitó probablemente el rendimiento ya que no se observó respuesta a los fertilizantes aún con densidades altas, excepto en lo referente a crecimiento de la parte aérea. El rendimiento por planta, el peso promedio de tubérculos, peso de parte aérea, número promedio de tallos y tubérculos/planta no fueron afectados por el fertilizante sino que decrecieron — todos ellos — con un incremento en población mayor a 18,500 plantas por hectárea.

REVIEW

Half the area of cassava production in Ghana is grown in the Forest Zone. Cassava is usually planted as an opening crop, interplanted with maize and cocoyams, after a fallow of secondary forest (Doku[8]). Although it is an important staple food, so little work had been done on the agronomy of cassava the Doku[8] could write "There are no records of experiments aimed at finding the best spacing, but somehow a 3 x 3 ft spacing has been accepted throughout the country as the best." Since then Koli[12] has conducted spacing and fertilizer trials throughout the country. Jennings[11] reviewed work on cassava in Africa.

In Senegal, Tardieu and Fauche[16] obtained highest yields with a population of 10,000 plants/ha, (1 x 1m). The Department of Agriculture Zanzibar[7] recorded highest yields with 11,900 plants/ha (3 x 3 ft), but in Argentina, Rodriguez *et al.*[14] recommended much higher populations of 13,300 to 20,000 plants/ha (1 x 0.75m or 1 x 0.5 m).

Yields of cassava can be increased by the use of green manure (Childs[3]; Doku[8]; Silvestre[15]) or farm yard manure (Briant[2]). Cours and Fritz[4] estimated that a 40 tonnes/ha. crop removes 85,62, 280 and 75 kg/ha each of N,P_2O_5, K_2O and CaO respectively. In field experiments cassava responds most to potash and phosphate (Tardieu and Fauche[16]; Doku[8]). De Geus[6] cited instances of responses to nitrogen but also evidence that too high a rate of nitrogen application may promote stem and leaf growth at the expense of root growth. Compound fertilizers have given good responses in a number of trials (FFHC[9]; Cours *et al.*[4]; Tardieu and Fauche[16]). A satisfactory ratio for N,P_2O_5 and K_2O is very important and De Geus[6] concluded that on the evidence available a ratio of 1:1:2 could generally be recommended. The optimum ratio

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will of course vary depending on the type of soil. In sand culture, Krochmal and Samuels[13] observed that phosphate induced the greatest response in yield but there was no marked response to potassium whereas nitrogen increased stem growth at the expense of roots.

MATERIALS AND METHODS

The two experiments reported were planted at the Arable Crops Farm of the University of Science and Technology Kumasi, Ghana on the Forest Ochrosols of the Akroso soil series (Bremmer[1]). The land was under a *Panicum maximum* grazed pasture for four years after clearing secondary forest and was prepared for planting by two disc ploughings, one disc harrowing and making ridges 90 cm apart. Each plot spanned ten ridges containing twenty cuttings per ridge. The length of the plot thus depended on the spacing of the cuttings on the ridge. The two outer ridges in each plot were guard rows. A randomized block design was used, replicated four times in both experiments. There were paths 90 cm wide between adjacent plots in the same block and the blocks were separated by paths 1.80 m wide.

Spacing treatments

	S1	S2	S3	S4	S5
Spacing within ridges (cm)	15	30	60	90	120
Plant population/ha	74,074	37,037	18,519	12,345	9,259

Fertilizer treatments

	F0	F1	F2
N	0	45	70
P_2O_5	0	45	70
K_2O	0	45	70

Experiment 1

Three spacings, S3, S4, S5, and two fertilizer treatments, F0, F1, were combined in all possible combinations to give six experimental treatments.

Experiment 2

Four spacings, S1, S2, S3, S4, and three fertilizer treatments, F0, F1, F2 were combined in all possible combinations to give twelve experimental treatments.

The dates of planting and harvesting and the rainfall during the growing season of the crop are as follows:

	Exp. 1	Exp. 2
Date of planting	3/4/70	29/3/71
Date of harvesting	5/4/71	10/4/72
Rainfall during season (cm)	127	124

The fertilizers were placed on the side of the ridges and covered after the cuttings had sprouted. Sprouting percentage for cuttings three weeks after planting was about 95 percent; any cutting which had not sprouted at this time was replaced. The cuttings were taken from the middle portion of the stems, each cutting containing five nodes, and were planted slanting with approximately half their lengths buried. The plots were weeded four times in each experiment at 3, 6, 9 and 15 weeks after planting. For the determination of yield and its components in Experiment 2, 80 plants from the middle 8 ridges of each plot were picked at random, carefully dug and the number of tubers and their fresh weights, the number of stems and the fresh weight of tops were determined for each plant. In experiment 1 cassava from the middle 8 ridges was weighed to determine the yield.

RESULTS AND DISCUSSION

The data for yield/ha, yield/plant, average tuber weights, weight of tops, average number of stems/plant and average number of tubers/plant were analysed statistically. Only some of the main effects, and none of the interactions were statistically significant, so only the main effect mean, their standard errors and indication of statistical significance are presented in Tables 1 and 2.

Spacing had a considerable effect on yield. The highest yield of tubers/ha was obtained at a spacing of 60 cm in both experiments (Table 1). Increasing the spacing beyond 60 cm (Exps. 1 and 2) or decreasing it (Exp. 2) lowered yield. This spacing is closer than the 91.4 x 91.4 cm spacing generally recommended throughout Ghana (Doku[8]), but it is near to the population of 20,000 p/ha recommended by Rodriguez *et al.*[14]. Similar results were obtained by Koli[12]. The relationship between plant population and yield appears to be of the parabolic kind with an optimum at around 18,500 plants/ha. Holliday[10] thought that for vegetative yield, the relationship between plant population and yield is asymptotic. Willey and Heath[17] however cited instances where the relationship between vegetative yield and plant population was parabolic. Yields per plant, average tuber weights, average number of tubers/plant, weight of tops and average number of stems/plant all decreased with an increase in plant population, indicating competition between plants even at the moderately low populations.

Fertilizers did not affect yields/ha, yield/plant or the weight and number of tubers (Table 2). There was however an increase in the weight of tops with an increase in fertilizer levels. This increase was however not at the expense of roots. This lack of response to fertilizers is either due to the fact that there were adequate nutrients in the soil or because water rather than nutrient supply was limiting yield.

At populations higher than 18,500 plants/ha yields cropped because the increased yield brought about by an increase in the number of plants/ha did not compensate for the associated decrease of yield/plant. This indicates intense competition between plants at the higher populations. This competition is not likely to be for the nutrients NPK since there was no response to these nutrients (Table 2) even at the highest populations, and no interactions between population and fertilizer levels. It was most likely competition for water. The rainfall received was on the lower range of the requirements for cassava, 100–200 cm. (De Geus[6]). At the higher plant populations the storage of starch in the roots was probably limited by inadequate water.

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TABLE 1

The main effects of spacing

	Exp. No.	15	30	60	90	120	S.E.(±)
Tuber yield/ha (tonnes)	1	-	-	40.1a	35.4b	20.3c	1.48
Tuber yield/ha (tonnes)	2	18.0c	27.9b	37.2a	31.2ab	-	1.95
Tuber yield/ plant(gm.)	2	251d	754c	2075b	2433a	-	87
Average tuber weights (gm.)	2	178b	302ab	403a	378a	-	34
Weight of tops (gm.)	2	624c	776c	1259b	1595a*	-	120
Average no of stems/plant	2	1.8b	2.0ab	2.3a	2.3a	-	0.07
Average no of tubers/plant	2	1.7c	3.2b	5.3a	6.4a	-	0.3

Means followed by different letters are significantly different (P = 0.01)

* Level of significance (P = 0.05)

TABLE 2

The main effects of fertilizers

					S.E.(±)
Tuber yield/ha.(tonnes)	1	31.6	32.3	-	1.15
Tuber yield/ha (tonnes)	2	29.8	28.2	27.2	1.69
Tuber yield/plant (gm)	2	1403	1345	1387	76
Average tuber weights(gm)	2	303	358	286	29
Weight of tops (gm)	2	904b	985b	1302a	104
Average no.of stems/plant	2	2.1	2.1	2.1	0.08
Average no.of tuber/plant	2	4.3	3.8	4.4	0.4

Means followed by different letters are statistically significant (= 0.05)