Evaluation of cassava varieties and effects of growth regulators on vegetative traits and yield

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ABSTRACT

Two experiments were conducted at the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Nigeria. In the first experiment, ten cassava varieties were evaluated in the field at two levels of NPK fertilizer mixture (0 and 300 kg ha^{-1}). In the second experiment, effects of three growth regulators (gibberellic acid, abscisic acid and indoleacetic acid) at five levels (0, 25, 50, 75 and 100 ppm) on the growth and yield of cassava were determined. (gibberellic acid, abscisic acid and indoleacetic acid)

The highest yielding and most responsive variety to fertilizer application was NR 8082. The growth regulators increased tuber yield and dry matter production at the lowest level of application (25 ppm), with indoleacetic acid producing the highest tuber yield at the final harvest. Gibberellic acid at 25ppm was the most efficient in terms of dry matter production.

Key words: Cassava varieties, NPK fertilizer, growth regulators and tuber yield.

INTRODUCTION

Cassava is an important crop, which is grown over a wide range of ecological zones in Nigeria. Nigeria is now the largest producer of cassava in the world. There has been intensive research conducted on the crop for several decades in Nigeria and many cultivars have been developed by the National Root Crops Research Institute (NRCRI), Umudike which has the mandate for cassava research and, also by the International Institute for Tropical Agriculture (IITA), Ibadan. The cultivars developed by NRCRI and IITA are designated as NR and TMS series respectively.

Thus a lot of agronomic studies have been done in the area of plant selection and breeding (Dixon *et al.* 1992; Hahn *et al.* 1993), fertilizers and their effects on dry matter accumulation and tuber yield (Obigbesan and Fayemi 1976; Njoku and Arene 1980; Njoku 1987; Ogbe *et al.* 1993), plant protection (Hahn 1978; Bock and Woods 1983; Hahn *et al.* 1993; Ogbe *et al.* 1993).

Plant growth substances have proved very useful in agriculture and any plant physiological process can be modified by the application of appropriate synthesized exogenous growth substances (Remison 1997). Akinyemiju & Adegoroye (1987) observed that effects of various environmental factors on tuber initiation and cellular component of tuber growth are mediated through hormonal responses. The hormones, auxin, gibberellin, ethylene and abscisic acid are among the several plant growth substances shown to be involved in tuber growth (Remison 1997). Sharma and Singh (1988) found that tuber yield of three varieties of potato increased with ethrel treatment.

Tuberization in cassava, which occurs as a result of swelling of the fibrous roots, can commence within 30-60 days (Ekanayake *et al.* 1997). Several physiological and metabolic processes have led to tuber initiation and root bulking and these can be modified by the application of growth regulators. Hence this study was carried out to evaluate cassava varieties and to determine the effects of growth regulators on the growth and tuber yield of cassava.

MATERIALS AND METHODS

In the first experiment, ten cassava varieties were evaluated at two levels of NPK fertilizer. The experiment was carried out at the Teaching and Research Farm, Ambrose Alli University, Ekpoma. The site had been under grass fallow for two years. The soil had a pH of 5.70, CEC of 6.28, 1.65% carbon, 0.15% Nitrogen, 9.O9ppm phosphorus, 0.22 m-equiv/100g potassium, 5. 16 m-equiv/100g calcium, and 0.44 m-equiv/100g magnesium.

Ten varieties used were NR 8212, NR8220, NR8210, NR 8230, NR 83107, NR 41044, NR. 8082, NR 8083, TMS 30572 and a local. A compound fertilizer, NPK 15.15.15, was applied at two rates, 0 and 300 kg ha^{-1}, 8 weeks after planting. The experimental layout was a 10 x 2 factorial design with four replicates. The crop was established from 25 - 28 June 1997 with cuttings of 25cm length, at a spacing of 1 x 1 m in plots of 6 x 8

m. A herbicide mixture of primextra and paracol was sprayed pre-emergence immediately after planting. The experiment was harvested from 30 June - 2 July 1998 and weights of tubers were recorded per net plot and sub-sampled for dry matter determination. Fresh samples (100g) were oven dried at 100 °C for 24h.

In the second experiment, variety NR 8082, which produced the highest yield in the first experiment, was used. Cuttings of 20cm in length were planted on 29 April 1999 in black polybags of 35cm x 40cm size and of 500cm guage filled with 13.0kg soil. Three growth regulators, gibberellic acid, abscisic acid and indoleacetic acid were each applied at five levels of 0, 25, 50, 75 and 100 ppm. Growth regulators were applied as foliar sprays at weekly intervals for 4 weeks, commencing 8 weeks after planting. The layout was a 3 x 5 factorial design with three replicates.

Data were recorded for vegetative characters (plant height, stem girth and number of leaves), tuber length, diameter and weight, and total dry matter yield. Dry weight was determined after oven drying at 100°C for 48h.

Relative yield (RY) of cassava was computed as

$$RY = \frac{\text{Weight of tubers with the application of growth regulators}}{\text{Weight without application}}$$

Relative growth (R), which is used to measure the efficiency of dry matter production, was calculated as

$$R = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

Where W_1 is crop dry weight at one harvest and W_2 is the dry weight at the next harvest and $T_2 - T_1$ is the difference in time units between the harvests in weeks.

RESULTS

In the field experiment, varieties differed significantly in yield, with the highest yielding varieties being NR 8082, TMS 30572 and NR 8212 in that order (Table 1). TMS 30572, which was recommended to farmers many years ago, gave the highest yield when fertilizer was not applied. The most responsive variety to fertilizer application was NR 8082 which gave *98.5%* more yield when fertilized. NR 8212 also responded to fertilizer application appreciably by 67.2%. The response of other varieties was small, with NR 8230, NR 83107 and TMS 30572 showing little or no response. Dry matter content of tubers ranged from 27.5-43.8% and fertilizer application had no significant effect (Table 1).

Table 1. The performance of cassava varieties as influenced by NPK fertilizer application.

Variety	Tuber yield (t/ha) NPK applied (kg/ha)			DM% NPK applied (kg/ha)		
	0	300	Mean	0	300	Mean
NR 8212	11.6	19.4	15.5	27.5	36.3	31.9
NR 8220	4.6	6.1	5.4	37.5	37.5	37.5
NR 8210	9.9	12.3	11.1	32.5	32.5	32.5
NR 8230	13.3	13.4	13.4	30.0	33.8	31.9
NR 83107	8.3	9.1	8.7	43.8	31.3	37.6
NR 41044	4.3	7.0	5.7	40.0	35.0	37.5
NR 8082	13.7	27.2	20.5	32.5	28.8	30.7
NR 8083	10.4	15.7	13.1	35.0	32.5	33.8
TMS 30572	17.6	18.6	18.1	35.0	30.0	32.5
Local	10.8	12.1	11.5	35.0	32.5	33.8
Se±			5.24			7.33

Table 2. Effect of growth regulators on plant height (cm) of cassava at 3 and 4 months after planting

MAP	Treatment	Level of application (ppm) 0	25	50	75	100	Mean	SE±
	Gibberellic acid (G_1)	33.4	38.2	39.7	34.7	40.8	37.4	
3	Abscisic acid (G_2)	40.2	37.4	29.7	35.0	36.4	35.7	3.37
	Indoleacetic acid (G_3)	34.7	36.2	39.2	37.5	36.7	36.9	
	Gibberellic acid (G_1)	38.0	40.8	42.3	36.8	41.5	39.9	
4	Abscisic acid (G_2)	42.8	40.8	36.4	36.8	37.3	38.8	2.57
	Indoleacetic acid (G_3)	40.0	40.3	42.5	41.0	38.3	40.4	

MAP - Month after planting

In the hormone treatment experiment, gibberellic acid increased plant height at almost all levels of application. On the other hand, abscisic acid decreased the height, while indoleacetic had no visible effect (Table 2). The number of leaves was significantly affected ($P<0.05$) by the growth regulators. For example, gibberellic acid increased the number, whilst indoleacetic acid decreased the number at all levels of application (Table 3). The increase in number of leaves with GA was more prominent at 4 months after planting (MAP) (6 more leaves at 100ppm) than the corresponding decrease with IAA. Abacisic acid had no effect. There was no particular pattern in the effect of growth regulators on stem girth (Table 4).

The weight of tubers was taken at monthly intervals from 4 to 7 months, and as expected weight increased with time (Table 5). The effects of growth regulators on weight of tubers were apparent as early as 4 MAP

Table 3. Effect of growth regulators on number of leaves of cassava at 3 and 4 months after planting

MAP	Treatment	Level of application (ppm)						
		0	25	50	75	100	Mean	SE±
	Gibberellic acid (G_1)	15.5	17.3	17.5	21.0	22.8	18.8	
3	Abscisic acid (G_2)	18.0	15.8	12.5	15.5	24.0	17.2	1.98
	Indoleacetic acid (G_3)	21.3	16.5	15.8	15.0	16.8	17.1	
	Gibberellic acid (G_1)	18.5	18.5	21.3	23.0	24.5	21.2	
4	Abscisic acid (G_2)	19.5	19.5	19.3	18.0	23.8	20.0	3.30
	Indoleacetic acid (G_3)	23.5	20.8	20.0	19.0	20.8	20.8	

MAP - Month after planting

Table 4. Effect of growth regulators on stem girth (cm) of cassava at 3 and 4 months after planting

MAP	Treatment	Level of application (ppm)						
		0	25	50	75	100	Mean	SE±
	Gibberellic acid (G_1)	2.0	2.6	2.8	2.6	3.1	2.6	
3	Abscisic acid (G_2)	2.5	2.9	2.8	2.5	2.9	2.7	0.33
	Indoleacetic acid (G_3)	2.7	2.5	2.4	2.3	2.4	2.5	
	Gibberellic acid (G_1)	2.8	2.9	3.0	2.9	2.9	2.9	
4	Abscisic acid (G_2)	3.1	2.7	2.8	2.8	2.8	2.8	0.24
	Indoleacetic acid (G_3)	2.9	2.8	3.2	2.9	2.9	2.9	

MAP - Month after planting

Table 5. Effect of growth regulators on fresh tuber weight (g/plant) of cassava

MAP	Treatment	Level of application						
		0	25	50	75	100	Mean	SE±
	Gibberellic acid (G_1)	15.0	30.0	50.0	30.0	75.0	40.0	
4	Abscisic acid (G_2)	15.0	25.0	55.0	25.0	15.0	27.0	18.17
	Indoleacetic acid (G_3)	20.0	20.0	70.0	50.0	30.0	38.0	
	Gibberellic acid (G_1)	21.1	25.8	103.9	52.5	75.9	55.8	
5	Abscisic acid (G_2)	48.3	113.7	59.0	48.4	86.5	71.2	46.0
	Indoleacetic acid (G_3)	32.8	84.4	68.8	116.0	67.8	74.0	
	Mean	34.1	74.6	77.2	72.3	76.7		
	Gibberellic acid (G_1)	66.2	128.4	158.1	110.7	103.7	113.4	
6	Abscisic acid (G_2)	70.2	185.4	62.5	51.8	29.5	79.9	
	Indoleacetic acid (G_3)	86.0	111.2	122.6	100.4	101.6	104.4	
	Gibberellic acid (G_1)	70.6	177.9	78.8	123.9	120.1	114.3	
7	Abscisic acid (G_2)	66.9	198.3	166.1	117.2	89.2	127.5	59.81
	Indoleacetic acid (G_3)	80.3	250.9	136.5	154.8	104.3	145.4	

MAP - Month after planting

when there was general increase at almost all levels of application. In subsequent months, however, the pattern of response was very clear, with higher yields obtained at low levels (25 and 50 ppm) of application. At the final harvest (7MAP), highest yields were obtained for all three growth regulators at 25 ppm. Indoleacetic acid gave the highest tuber weight, whilst gibberellic acid gave the least. The yields obtained with the application of 25 ppm of indoleacetic acid, abscisic acid and gibberellic acid were 212.5%, 196.4% and 152.0% greater than the control respectively at the final harvest.

The growth regulators did not affect the length and diameter of tubers. The growth regulators also had no significant effect on dry matter yield of cassava at 4 and 5 MAP, but effects were significant at 6 and 7 MAP (Table 6). At 6 MAP, abscisic acid, gibberellic acid and indoleacetic acid treatment recorded the highest dry matter yields at 25, 50 and 75 ppm respectively. By 7 MAP when growth was at optimum level, growth regulators produced the highest dry matter at 25 ppm (Table 6).

Table 6. Effect of growth regulators on dry matter yield of cassava (g/plant)

MAP	Treatment	Level of application (ppm)						
		0	25	50	75	100	Mean	SE±
	Gibberellic acid (G_1)	22.1	17.5	51.1	37.1	46.7	34.9	
4	Abscisic acid (G_2)	24.5	21.3	22.9	17.2	44.9	26.2	15.88
	Indoleacetic acid (G_3)	26.9	21.8	44.7	19.2	25.5	27.6	
	Gibberellic acid (G_1)	28.3	44.7	46.2	32.0	20.9	34.4	
5	Abscisic acid (G_2)	33.6	51.9	35.1	27.9	41.6	38.0	15.88
	Indoleacetic acid (G_3)	31.7	41.4	41.8	54.3	26.1	39.1	
	Gibberellic acid (G_1)	39.4	71.9	94.9	82.4	59.0	69.5	
6	Abscisic acid (G_2)	46.3	115.7	33.8	32.4	21.1	49.9	19.62
	Indoleacetic acid (G_3)	43.3	64.4	69.3	71.7	57.7	61.3	
	Gibberellic acid (G_1)	42.1	94.5	45.2	64.1	53.3	59.8	
7	Abscisic acid (G_2)	46.8	107.1	80.6	64.0	27.4	65.2	29.91
	Indoleacetic acid (G_3)	44.8	111.9	79.7	81.6	51.3	73.9	

MAP - Month after planting

Relative growth rates increased in the control from 4 to 6 MAP. But, the increase from six to seven months was small (Table 7). Relative growth rates were highest for plants treated with three growth regulators at the lowest level (25 ppm), particularly at 4 to 6 MAP; rate was highest, on average, for gibberellic acid.

Table 7. Relative growth rates (g/g/wk) as influenced by the application of growth regulators by cassava

MAP	Treatment	Level of application (ppm)					
		0	25	50	75	100	Mean
	Gibberellic acid (G_1)	0.061	0.234	-0.025	-0.037	-0.201	0.006
4-5	Abscisic acid (G_2)	0.078	0.221	0.107	0.121	0.019	0.102
	Indoleacetic acid (G_3)	0.041	0.160	-0.017	0.260	0.006	0.090
	Gibberellic acid (G_1)	0.083	0.119	0.180	0.237	0.259	0.176
5-6	Abscisic acid (G_2)	0.080	0.201	-0.009	0.037	-0.170	0.028
	Indoleacetic acid (G_3)	0.078	0.112	0.126	0.069	0.198	0.117
	Gibberellic acid (G_1)	0.017	0.069	-0.186	-0.063	-0.028	-0.038
6-7	Abscisic acid (G_2)	0.002	-0.019	0.217	0.170	0.066	0.087
	Indoleacetic acid (G_3)	0.008	0.137	0.035	0.033	0.029	0.048

MAP - Month after planting

DISCUSSION

The cassava variety TMS 30572, which is currently recommended to farmers in Nigeria, did not respond to fertilizer application in this trial. One reason for its suitability and for various ecological zones may be its adaptability to grow in poor soil hence it is usually grown by farmers without the application of fertilizers. However, for large scale cultivation of the crop on farmlands, a variety such as NR 8082 responsive to fertilizer application (Table 1), would be more suitable. The variety yielded over 20 t ha^{-1} on average and gave 98.5% more yield when fertilized. This makes it a clear candidate for recommendation to farmers, if similar yield is sustained in trails across other ecological zones and seasons.

Even though the number of leaves increased in the polybag experiment by over 32% and 47% when gibberellic acid was applied at 100 ppm relative to control treatments at 3 and 4 MAP respectively, there was no corresponding increase in photosynthetic activities or translocation of assimilates to storage roots, as tuber yield decreased with high levels of gibberellic acid application. The increase in height and number of leaves with GA application is a confirmation of the role of gibberellins in promoting vegetative growth in plants (Remison 1997). This has been demonstrated in crops such as soyabeans (Anderson *et al.* 1988; Remison *et al.* 1991a, 1991b) and coconut seedlings (Remison 1984).

That the activity of growth regulators in boosting yield may not have any relationship with increase in leaf production, is further illustrated by indoleacetic acid which reduced the number of leaves but greatly increased tuber weight. Infact IAA increased tuber weight most at 7 MAP with the lowest level of application (Table *5).* It may well be that the fewer leaves were more photosynthetically active and efficient in the transfer of assimilates to storage roots. There is evidence of increased chlorophyll content in leaves with the application of growth regulators (Remison *et al.* 1991b) and increased photosynthetic rates (Arteca and Dong 1981). Sharma and Singh (1988) have also shown that there was more translocation of photosynthates towards tubers in potato varieties, when low concentration of ethrel was applied. Indeed, the mechanism of growth regulation is all very complex. One striking effect of their application is that the cell wall of plant tissues is made more plastic and the popular theory has been that cell extension results from water intake. However, this theory is certainly too simple and other effects of hormones include increasing respiration rate and altering nucleic acid metabolism, induction and promotion of the synthesis of RNA and proteins, formulation of proteolytic enzymes, etc. (Fog 1966; Remison 1997).

The highest tuber yields were obtained at the final harvest for all three growth regulators at the lowest level of application (25 ppm). That yield is increased by only low levels of application of growth regulators, has been confirmed for many other crops, e.g. tomato (Arteca and Dong 1981), soyabean (Remison *et al.* 1991a, 1991b) and potato (Sharma and Singh 1988).

Total dry matter accumulation increased up to 6 MAP and there was no appreciable increase at 7 MAP partly due to leaf fall. Relative growth rate values showed that plants were efficient producers of dry matter up to 6 MAP. Gibberellic acid at 25ppm was the most efficient producer of dry matter, the highest average relative growth rate being 0.141 g/g//wk. Very few studies of growth regulation studies are available in root crops. For instance, Sharma and Singh (1988) found that tuber yield of three potato varieties increased with ethrel treatment. The authors are not aware of any work on growth regulation studies in cassava. There is clearly a need for more studies in this area not only with single applications but with mixtures of growth regulators. Experiments are in progress in this direction.

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