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Full Length Research Paper

Impact of global warming and crop factors on the growth and productivity of four cassava (*Manihot esculenta* Crantz) cultivars in Nigeria

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The integrated effects of weather change (Global warming), genotypic factors and cultivars on the growth and productivity of cassava (*Manihot esculenta* Crantz) were investigated in South-eastern Nigeria in 1999/2000 and 2000/2001 cropping seasons. Plant height (m), number of roots and fresh root yields (t/ha) differed among the seasons in response to global warming and were dependent on a combined optimum rate of each individual treatment. The optimum plant height (m) obtained during the two seasons ranged from 2.0 to 2.1 M and were obtained by the interaction of TMS 30572 x 750 kg/ha stake weight x 3 shoots per stand. The highest fresh root yield of 28.0 and 13.6 t/ha were obtained by the interaction of cultivar NR 8082 x 875 kg stake weight x 3 shoots per stand. The combined analysis of variance for fresh root yields showed significant (P = 0.05) mean squares for cultivar, stake weight, number of shoots per stand and seasons (years). There was cultivar x stake weight x number of shoot x season interaction, indicating that the yields of the treatments responded differently relative to each other in different years. Higher plant height (2.1 m) and fresh root yield (28.0 t/ha) were obtained in 1999/2000 than in 2000/2001(1.9 m and 13.6 t/ha). Crop factors and weather change tremendously determined growth and productivity of cassava in Nigeria. Crop factors and weather were responsible for the variations in cassava yields in Nigeria.

Key words: Cassava, productivity, climatic factor, south eastern Nigeria, cultivars.

INTRODUCTION

The atmosphere, vegetation and soils contain different stocks of carbon. Depletion (small losses) and over production (excess production) from the pool could have significant impact on the seasonal atmospheric carbon dioxide concentration. Therefore, the response of crops to the global warming (the seasonal changes in the weather) is of critical importance to the growth and productivity of the cassava. Plants utilize a lot of carbon dioxide in the manufacture of photosynthesis and for production of food for humans. Many factors of the environment such as temperature, sunshine, rainfall, relative humidity, rate of decomposition, changes in atmospheric composition, etc affect productivity of the crops. Recent studies have indicated the future consequences of alternating the global atmospheric condition due to global warming (Smith et al., 2008). The cassava (*Manihot esculenta* Crantz) is one of the most useful root crops in the tropics. It is the major source of carbohydrate for Nigerians. Besides its use as food, it is a major industrial raw materials for production of starch, alcohol, pharmaceutics, gums, confectionaries and livestock feed (Eke-okoro et al., 1999). Nigeria is currently the World's largest producer of cassava with annual production of 44 million metric tones (CBN, 2004).

Cassava (*M. esculenta* Crantz) plant grows and produces well in Nigerian environment. However, it shows different growth behaviour and yield in different years as a result of differences in the annual weather condition (Eke-Okoro et al., 1999). In India, Salvi et al. (1984) also reported differing growth of the cassava. Annual conditions of rainfall, temperature, sunshine and relative humidity influence the growth and yield of cassava. Therefore, weather is a vital factor in its cause productivity. Any alternation due to global warming will serious consequences on its productivity.

Sunshine is the most important growth factor as far as

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temporal factors (e.g., relative humidity) of crop growth is concerned (Simwambana et al., 1995). Work at CIAT, showed that shading 5-months old cassava plant to 50% of full sunlight had little effect on leaf appearance rate and final leaf size (cm) but reduced leaf longevity and leaf area index (Cock and Rosas, 1975). Similarly, Fukai et al. (1984) recorded reduction in leaf area index, root number and harvest index under low solar input. The current global warming invariably will automatically affect the growth of these yield attributes.

Temperature is another factor which affects the growth of plant (Salvi et al., 1984). Keatings and Evenson (1979) reported that low soil temperature (-2℃) delays emergence while low air temperature (5℃) decreases growth rate of cassava to (0) from July to September in Australia. Large seasonal differences in temperature cause variation in growth and subsequent yield of cassava (Keatings and Evenson, 1979; Fukia et al., 1984). With the increasing Global warming, temperature is bound to be very high and this will in turn affect the performance of cassava as a crop.

Water regime of an environment is another important factor which affects the growth of crops (Savi et al., 1984). Differential soil water and nutrient regime have been reported to affect yield stability in cassava (Cock, 1985). Although this plant is extremely tolerant to water stress, and a long dry period has been reported to decrease yield (Connor et al., 1981). Similarly, prolonged moisture deficiency has been observed to reduce growth, development and root yield (CIAT, 1980; El-Sharkawy et al., 1992). The worsening trend in climatic change with consequent high temperature will subject water to high evaporation rate thereby limiting the essential medium of plant growth (Okpeke, 2009). Agronomic/cultural practices and genotypes influence yield of most crops. Toro and Atlee (1985) and Eke-Okoro et al. (2001), stated that in any production system, the size and quality of the stake are of fundamental importance for high yields. Poor quality planting material is often associated with marginal growth and productivity of cassava (Eke-Okoro et al., 1999). The worsening climatic change with consequent limits in availability of essential environmental factors will affect the performance of crops including cassava. Seasonal fluctuation of atmospheric carbon, rainfall, temperature and sunshine; cultural practices and crop genotypes tremendously influence the growth and yield of cassava.

Aim of this paper is to examine the impact of the global warming and related factors on the growth and productivity of cassava plant under Southeastern Nigeria conditions.

MATERIALS AND METHODS

The study was carried out at the National Root Crops Research Institute (5° 29' N; 7° 32' E 122 M) Umudike, Nigeria, in 1999/2000 and 2000/2001. It has annual rainfall of 1800 - 2200 mm with a 59 year average of 2159 mm. The soil texture of the experimental area is acid sandy loam. Two weights of cassava stakes (75 and 88 g) and two shoot numbers (maintaining 2 and 3 number of shoots per stand) of three improved cassava cultivars (TMS 30572, NR 8082 and NR 8083) were evaluated. The stake weights were equivalent to a rate of 750 and 875 kg/ha and were achieved by varying the stake lengths (Eke-Okoro et al., 2001). Shoots per stand were varied from 2 to 3 by pruning new sprouts starting from one week after shoot emergence. Fields were inspected regularly to maintain the right number of shoots per stand. Planting began on 10th of June of each season. A total of 60 stakes representing each weight was planted in a 6 × 10 m plot at 1 m^2 spacing. A (3 × 2 × 2) factorial pattern of a randomized complete block design with four replications was used (Wahua, 2001). There were 12 treatment combinations. An application of NPK (mg) fertilizer in the ratio of 12:12:17:2% was applied at 8 weeks after planting at the rate of 400 kg/ha. In addition to the application immediately after planting to control weeds, plots were manually weeded twice at 5 and 9 months after planting. Data collected include establishment count at 4 weeks after planting; plant height (m), number of roots and fresh root yields (t/ha) at 12 months after planting. Fresh root yield (t/ha) was obtained and weighed with weighing balance.

The data were analyzed according to the procedure for a factorial experiment in a randomized complete block design outlined by Steel and Torrie (1980) using a SAS (2000) statistical software computer programme. Means were compared by LSD (5%) test when F-values were significant.

RESULTS

Weather condition

The total rainfall decreased from 2701.3 mm in 1999 to 2190.2 mm in 2001. The total rainfall in 1999/2000 and 2000/2001 was similar in trend with a marked difference of 511.1 mm of rainfall in favour of 1999/2000 (Table 1). The total maximum air temperature increased from 373℃ in 1999 to 381 in 2001 while the total minimum air temperature increased from 272℃ in 1999 to 276℃ in 2001. The total sunshine hours decreased from 54.4 h in 1999 to 53.4 h in 2001. However, there were no marked differences in sunshine hour in both years.

Growth of cassava

Changes in plant establishment and height of cassava due to effect of cultivar, stake weight and number of shoots per stand were not significant (Tables 2, 3 and 4). The interaction of cultivar, stake weight and number of shoots per stand did not significantly influenced percent establishment. However, the interaction of cultivar, stake weight and number of shoots per stand improved plant heights (20 to 2.1 m). Cassava cultivars – NR8083 or TMS 30572 × 750 kg/ha stake weight × 3 shoots and NR8083 × 875 kg/ha stake weight × 3 shoots improved plant height slightly.

Fresh root yield and yield components

The main effects of cultivar and stake weight on the number of roots generated were significant (Tables 2 and 3). Cassava cultivar NR8083 gave the highest number of roots

Table 1. Total rainfall, temperature and sunshine from 1999 to 2001 at Umudike, Nigeria.

	1999				2000				2001			
	Temperature (O°C)				Temperature (0°C)				Temperature (O°C)			
	MAX	MIN	Rainfall amount (mm)	Sunshine (h)	MAX	MIN	Rainfall amount (mm)	Sunshine (h)	MAX	MIN	Rainfall amount (mm)	Sunshine (h)
JAN	32	23	45.6	5.4	32	23	14.8	4.7	33	21	0.0	6.2
FEB	32	24	98.1	5.6	35	22	0.9	4.2	35	23	7.8	4.9
MAR	32	23	203.4	5.9	35	23	13.6	4.4	34	24	175.9	5.1
APR	32	23	192	4.5	33	24	164.5	5.1	33	24	224.1	6.1
MAY	32	23	319.9	5.4	32	24	153.6	5.6	32	24	194.3	5.7
JUN	31	23	296.6	4.5	31	23	265.5	4.9	31	23	522.7	4.2
JUL	30	22	284.4	3.5	30	23	265.2	2.6	29	23	273.5	2.5
AUG	30	22	382.2	3.6	30	24	216.9	2.2	29	23	179	1.4
SEP	29	22	395.3	2.2	30	24	277.5	2.3	30	23	317.2	2.5
OCT	30	22	433.7	3.2	31	24	228.4	3.2	31	23	277.1	3.6
NOV	31	23	50.1	4.9	33	25	75.1	5.6	32	23	18.6	5.2
DEC	32	22	0.0	5.7	32	21	3.8	5.9	32	22	0.0	6.5
TOTAL	373	272	2701.3	54.4	384	280	1680.6	50.7	381	276	2190.2	53.9

Table 2. Percent establishment, plant height (m), number of roots, and fresh root yield (t/ha) as affected by cassava cultivars in South eastern Nigeria.

Cassava cultivars	Percent establishment		Plant height (m)		Number of root		Fresh root yield (t/ha)	
	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
TMS 30572	89.1	90.2	1.9	1.9	113.3	93.9	10.5	7.1
NR 8082	87.1	88.9	1.8	1.8	246.6	193.7	24.8	13.8
NR 8083	91.3	87.0	1.9	2.0	123.9	79.8	9.0	8.0
S.E	2.11	1.14	0.07	0.07	14.33	11.1	0.70	0.78

number of roots (246.6 and 192.7) in the two seasons. There was no significant main effect of stake weight and number of shoots per stand on the number of roots produced. Differences in the number of roots was generated by the main effects of cultivar, stake weights and number of shoots per stand were evident with 1999/2000 being higher than 2000/2001 (Tables 2, 3 and 4). The interaction of treatments produced tremendous disparity in the number of roots generated (Table 5). The interaction of cultivars NR 8083 × 875kg/ha stake weight × 3 shoots per stand produced the highest number of roots (Table 5). Generally, the number of roots produced by the above treatment interaction was better in 1999/2000 than 2000/ 2001. Similar trend in the number of roots generated was obtained in 1999/2000 than in 2000/2001 across all other treatment interactions. The main effect of cultivar, on the total fresh root yield differed significantly (Table 2) but this trend was not the case with stake weight and numbers

Table 3. Percent establishment, plant height (m), number of root and fresh root yield as affected by stake weight (kg/ha) in 1999/2000 and 2000/2001 in South eastern Nigeria.

Stake weight kg/ha)	Percent establishment		Plant height (m)		Number of roots		Fresh root yield (t/ha)	
	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
750 kg/ha	88.6	89.6	1.9	1.9	163.6	121.7	14.0	9.5
850 kg/ha	89.7	88.5	1.9	1.9	158.9	122.6	15.5	9.7
S.E.	1.72	1.71	0.06	0.06	11.70	9.06	0.57	0.64

Table 4. Percent establishment, plant height (m), number of root and fresh root yield (t/ha) as affected by the number of shoots per stand in 1999/2000 and 2000/2001 in South eastern Nigeria.

Number of shoot per stand	Percent establishment		Plant height (m)		Number of roots		Fresh root yield (t/ha)	
	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
2 Shoots	89.9	88.9	1.8	1.9	160.8	108.4	14.2	8.6
3 Shoots	88.3	99.8	1.9	1.9	161.8	135.8	15.3	10.7
S.E.	0.67	0.66	0.61	0.60	11.70	9.06	0.57	0.64

Table 5. Interaction effect of cultivars stake weight number of shoot per stand on percent establishment, plant height (m) number of roots and fresh root yield (t/ha) in 1999/2000 and 2000/2001 in South Eastern Nigeria.

Treatment					Percent establishment		Plant height (m)		Number of roots		Fresh root yield	
Cassava cultivar		Cassava stake weight (t/ha)		No. of shoot s per stand	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
TMS 30572	X	750kg/ha	X	2 shoots	88.3	90.1	1.8	1.7	102.5	67.0	9.2	5
TMS 30572	X	750kg/ha	X	3 shoots	90.3	88.0	2.0	2.1	131.8	129.0	11.5	10.5
TMS 30572	X	850kg/ha	X	2 shoots	87.2	90.3	1.9	1.9	102.5	70.7	9.7	6.4
TMS 30572	X	850kg/ha	X	3 shoots	90.8	86.6	1.9	1.9	116.5	99.0	11.7	8.9
NR 8082	X	750kg/ha	X	2 shoots	86.5	86.4	1.8	1.9	239.0	153.7	23.5	12.1
NR 8082	X	750kg/ha	X	3 shoots	83.8	90.8	1.8	1.9	246.3	121.7	23.9	13.0
NR 8082	X	850kg/ha	X	2 shoots	87.3	83.9	1.7	1.8	238.8	196.7	23.8	13.3
NR 8082	X	850kg/ha	X	3 shoots	90.8	87.6	1.8	1.7	262.3	217.7	28.0	13.6
NR 8083	X	750kg/ha	X	2 shoots	92.5	90.6	1.9	1.9	174.0	70.0	8.7	6.8
NR 8083	X	750kg/ha	X	3 shoots	90.3	95.2	2.1	2.0	88.0	87.7	7.3	8.1
NR 8083	X	850kg/ha	X	2 shoots	88.3	90.1	1.9	1.9	107.8	92.3	10.7	7.8
NR 8083	X	850kg/ha	X	3 shoots	94.0	88.3	2.0	2.1	125.7	69.0	9.5	9.3
S.E					4.40	4.37	0.12	0.14	29.89	22.70	14.6	1.60

Table 6. Combined analysis of variance of fresh root yield grown for 2 years (1999 - 2001).

Source of variation	Degree of Freedom	Mean square	F-cal pooled error mean square
Year	1	77.4326	4.17 *
Cultivar	2	43.1885	2.33ns
Shoot Number	1	60.1712	3.24 *
Stake Weight	1	14.8760	0.79ns
Cultivar X Shoot Number	2	18.4525	0.99ns
Cultivar X Stake Weight	2	14.1549	0.74ns
Stake Weight X Shoot Number	1	42.6260	2.24ns
Cultivar X Stake Weight X Shoot Number	2	131.2000	7.07 *
Rep. (cultivar X year)	18	42.7211	2.30n
Replication	2	35.6915	1.92ns
Pooled error	36	18.5471	1.92ns

Significant at P = 5%; ns = not significant; Rep. = Replication.

of shoots per stand (Tables 2 and 3). Cassava cultivar NR8082 produced the highest fresh root yield of 24.8 and 13.8 t/ha in 1999/2000 and 2000/2001, respectively (Table 2). Cultivars TMS 30572 and NR 8083 maintained similar yields in the two seasons. However, plants with highest stake weight and shoot number maintained a non-significant yield differences in respective seasons. The effect of weather on the performance of the cultivars was evident. The highest fresh root yields of (9 to 24.8 t/ha) were obtained in 1999/2000 cropping season. The interactions of cultivar, stake weight and number of shoots per stand on fresh root yields were significant (Table 5). The interaction of NR8082 × 875kg/ha stake weight × 3 shoots per stand significantly sustained the highest fresh root yield (28.0 t/ha in 1999/2001 and 13.6 t/ha in 2000/2001). A combination of NR 8082 × 750 kg/ha stake weight × 3 shoots per stand gave the second best fresh root yield among the treatments. Generally fresh root yields (t/ha) were tremendously higher in 1999/2000 when compared with 2000/2001.

DISCUSSION

Growth indices such as plant establishment and plant height (m) were not altered across the seasons. This could be attributed to similarity in temperature condition and sunshine hours in both 1999/2000 and 2000/2001, which among other factors accelerated the initial sprouting ability, breaking of bud dormancy, plant vigour and plant establishment (Eke-okoro et al., 1999; Njoku and Muoneke, 2008). Evidence of variability in the number of roots produced by individual cultivars during the two cropping seasons was indicated by the significant yield differences recorded (Table 1). The result of the combined analysis presented in Table 6 confirmed that the indicated yield differences resulting from differences in the weather condition (year effect) during the cropping seasons. The interaction of agronomic factors (agronomic treatments) and weather condition produced higher values of number of roots and fresh root yields in 1999/2000 than 2000/2001. This was due to the integration effects of agronomic treatments and year effect (weather change) as this was not possible with individual treatments alone. The result of the combined analysis of variance indicated that a substantial proportion of the observed agronomic factors (treatments) x season (year) effect could be attributed to differences in weather condition of the seasons (climate change) and traits of the cultivar, stake weight and number of shoots. The combined analysis of variance for fresh root yield showed significant mean square for cultivar and cultivar x stake weight x shoot number x year interaction indicating that the yield of agronomic technologies responded differently relative to each other in different seasons (years) in response to changing global climatic conditions. Smith et al. (2008) indicated the changes in carbon dioxide concentration due to climate change. Although, there was fairly uniform sunshine in 1999/2000 and 2000/2001, the higher root number and fresh root yield obtained in 1999/2000 could be a response to higher rainfall received by the crops in 1999/2000. This trend of response showed that better productivity of cassava was achieved in 1999/2000 season than 2000/2001 due to seasonal changes in weather condition. Eke-Okoro et al. (1999) and Salvi et al. (1984) reported differences in the annual growth and productivity of cassava in Nigeria and India, respectively. Increasing Global climate change worsened the situation in 2001. The annual differences in rainfall amount in both cropping seasons predisposed the treatments to differential performances in favour of interaction of treatments and weather condition. This suggests that the productivity of cassava was driven by the annual differences in weather condition of rainfall and sunshine in response to climate change in our environment. The results of this study emphasized that differences in the treatments (agronomic factors) and annual weather conditions were responsible for differences in the growth and productivity of cassava. The appropriate combination (integrated) of agronomic technologies and uniform condition of rainfall and sunshine were very important in reducing variations and increasing growth and productivity in cassava. Therefore, weather change is of critical importance when assessing growth and productivity of cassava in recent times.

REFERENCES

CBN (2004). Central Bank of Nigeria. Annual Report and Statement. Central bank of Nigeria, Lagos, Nigeria pp. 27-32.

CIAT (1980). Centro International de agricultural Tropicale. Annual Report, Cali, Colombia p. 93.

Cock JH (1985). Stability of performance of cassava genotypes. In: Cassava breeding: a multidisciplinary review. Proc. Workshop held in Phillipines 4-7: 100-106.

Cock JH, Rosas L (1975). Ecophysiology of cassava. In: Symposium on ecophysiology of tropical crops. Communication Dir. CEPLAC, Rodovia, Tiheus- Itabuna, Balia, Brazil p. 14.

Connor DJ, Cock JH, Parra GE (1981). Response of cassava to water shortage, Growth and yield. Field Crops Res. 4: 181-200.

Eke-Okoro ON, Okereke OU, Okeke JE (1999). Effects of weather change and planting sett on growth and productivity of cassava in South-eastern Nigeria. Afr. J. Root Tuber Crops 3 (2): 34-38.

Eke-Okoro ON, Okereke OU, Okeke JE (2001). Effect of stake sizes on some growth indices and yield of three cassava cultivars. J. Agric. Sci. Cambridge 137: 419-426.

El-Sharkawy MA, Hernandez AP, Hershey C (1992). Yield stability of cassava during prolonged mid-season water stress. Exp. Agric. 28: 165-174.

Fukai S, Alcoy AB, Lambelo AB, Patterson RD (1984). Effects of solar radiation on growth of cassava. 1. Canopy development and dry matter growth. Field Crops Res. 9: 347-360.

Keatings BA, Evenson JP (1979). Effect of soil temperature on sprouting and Sprout elongation of stem cuttings of cassava. Field Crops Res. 2: 241-251.

Njoku DN, Muoneke CO (2008). Effect of cowpea planting density on growth, yield and productivity of component crops in cowpea/cassava intercropping system. Agrosci. J. 7 (2): 106-113.

SAS (2000). Statistical analyses system User's guide. Version 2000. Cary, N.C. United States of America.

Simwambana SMC, Ekanayake IJ, Ferguson TU (1995). Effects of shading on growth and flowering behavior of four cassava genotypes. Afr. J. Root Tuber Crops 1 (1): 19-25.

Smith P, Fang C, Dawson JC, John B (2008). Impact of global warming on soil organic carbon. Adv..Agron. 97: 1-43.

Toro MC, Atlee CB (1985). Agronomics practices for cassava production: In: Cock, J.H and Reyes JA. (eds). Cassava research production and utilization. CIAT Cali, Colombia pp. 207-214.