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Maize Vegetative Growth Response to Poultry Manure and Sowing Date during Delayed onset of Rainfall in a Humid Agroecology of Nigeria

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Keywords: *delayed onset, maize, moisture deficit, poultry manure, rainfall, sowing date.*

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Abstract- Soil moisture deficit due to delayed onset of rainfall creates stress conditions at the early season when maize is at the early vegetative stage of growth. In 2009 and 2010 the impact of poultry manure and sowing date on maize vegetative growth during delayed onset of rainfall was assessed in a rainforest agroecology of Nigeria. The treatments comprised four sowing dates (February 28, March 15, March 30 and April 14), three maize varieties (TZE COMP3C3, TZL COMP4C3 and OKA AWAKA) and two poultry manure rates (0 and 10 tons ha^{-1}). These treatments were arranged as a split-split plot and laid out in randomized complete block design with three replications. Maize vegetative parameters, including height, number of leaves, leaf area and stem dry weight were significantly affected by year of cropping, thereby indicating inter-annual variability in climatic variables. At 42 days (6 weeks) after planting, soil moisture deficit reduced height, number of leaves and leaf area by 55.7, 22.2 and 65.5 % respectively and consequently led to 80.3 and 73.0 % reduction in dry weight of stem and leaf respectively when maize was planted on February 28 compared to March 30. However, application of poultry manure reduced the impact of moisture deficit and led to improvement in height, number of leaves, leaf area, stem and leaf dry weight by 131.6, 44.2, 184.3, 211.4 and 215.8 % respectively. This study shows that during delayed onset of rainfall in the rainforest agroecology of Nigeria, maize vegetative growth and dry weight can be enhanced through delayed planting and application of moisture conservation strategies including poultry manure application.

Keywords: delayed onset, maize, moisture deficit, poultry manure, rainfall, sowing date.

I. Introduction

Change in rainfall pattern is a manifestation of climate change (Jones and Thornton, 2003). It is characterized by delayed onset and early cessation and leads to the shortening of the growing season across southern (humid) Nigeria in particular (NIMET, 2008). Delayed onset of rainfall causes soil moisture deficit, high solar radiation, reduced humidity and high evapotranspiration there by creating moisture stress condition at the early season (Campos *et al.*, 2004). Solar radiation receipts in this region are highest around October/November (rainfall cessation) and February / March (rainfall onset) while lowest values are recorded around June/July (rainfall peak) (Augustine and Nnabuchi, 2010). With a mean maximum temperature between 30°C and 32°C almost through the year (Adejuwon, 2004), evapotranspiration exhibits similar trend as solar radiation with high rates between February and March and lowest rates between July and September (Chinekeet *al.,* 2011). The tendency therefore is for spells of soil moisture deficit to occur in these humid areas (Adejuwon, 2004) particularly between February and April. According to Adikuru*et. al.*,(2020), delayed onset of rainfall in Owerri, southeastern Nigeria is the consequence of a shift in rainfall pattern within the months of February and March and it results in moisture deficit. Prior to the incidence of climate change, maize was traditionally planted at the beginning of the rains in March. Therefore the period of delayed onset of rainfall when moisture deficit often occurs in this location, coincides with the early vegetative stage of maize growth. The vegetative stage of maize development is physiologically designed for interception of radiant energy and conversion of same to dry matter (Maddoni and Otegui, 1996; Moore *et. al*., 1998) which is later remobilized to the kernels during the period of rapid kernel growth (Setter and Meller, 1984). Hence, moisture stress at the vegetative growth stage causes reduction in total biomass accumulation (Otegui *et. al*., 1995; Khan *et. al*., 2001) through its effect on cell enlargement and cell division and consequently leaf expansion (Jones, 1992; Nonami, 1998).The high sensitivity of leaf growth to water deficits is considered to be a 'stress avoidance' mechanism, because it enables plants to tolerate severe drought conditions by saving soil water (Lopes *et. al*., 2011).The objective of this study was to assess the performance of maize planted at different dates with a view to determine the impact of moisture deficit on the vegetative growth of maize in Owerri.

II. Materials and Methods

a) Location of Experimental Site

This experiment was carried out in 2009 and 2010 at the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The experimental site which is in the rainforest ecological zone of Nigeria lies

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between latitudes 5^0 20'N and 5^0 27'N and longitudes 7^0 00'E and 7^0 07'E. The location which is found in Southeast Nigeria, experiences annual rainfall of 2500 mm and minimum and maximum annual ambient temperature of 20°C and 32°C respectively, while the soils are classified as Arenic Hapludiult (USDA, 1999). The rainfall pattern is seasonal and double maxima with a short dry season period (commonly referred to as August break) from July to August (Odjugo, 2005).

b) Treatments and Design of the experiment

The experiment which was laid out as a split-split plot in randomized complete block design comprised four sowing dates (February 28, March 15, March 30 and April 14), two poultry manure rates (0 and 10 tons per hectare) and three maize varieties. The treatment combinations obtained (24)were replicated three times. While maize varieties constituted the sub-subplot, poultry manure was the sub-plot treatment and sowing date the main plot. Each sub-subplot measured 3.75 x 3.0 m^2, subplots measured 3.75 x 11.0 m^2 and main plots measured 8.5 x 11.0 m^2. The International Institute for Tropical Agriculture in Ibadan Nigeria supplied the seeds of the maize varieties- TZE COMP3C3 (early maturing) and TZL COMP4C3 (late maturing)- while the third variety (OKA AWAKA) was a landrace from Awaka in Owerri North local government area of Imo state, Nigeria.

III. Data Collection & Statistical Analysis

A population of 53,333 plants ha^{-1} was established by planting two maize seeds per hill at a spacing of 0.75 x 0.25 m and thinning the seedlings to one per hill at three weeks after planting (WAP). After growing for 6 weeks (42 days), the plant height, number of leaves, leaf area, stem and leaf dry weight of the maize varieties were measured. Subsequently, analysis of variance procedures for a split-split plot design using Genstat 7.2 (Discovery Edition 3) were employed in analyzing the data. Means were separated using the least significant difference.

IV. Results and Discussion

a) Description of climatic variables at the study location

The total rainfall received at the study site for the period of the experiment (February – August) in 2009 and 2010 was 1,816.4 and 1191.9 mm respectively. In 2009, the location experienced average maximum and minimum temperature of 34.5 and 17.4°C, while in 2010 it was 37.3 and 18.3°C respectively (Table 1). Average relative humidity for the location was 79.5 and 76.6 % for 2009 and 2010 respectively. Obviously, the location received more rainfall in 2009 than 2010. This resulted in higher relative humidity and lower temperature (79.5 % and 34.5°C) in 2009. Therefore drier conditions were experienced in 2010 when compared to 2009 thereby indicating inter-annual variability in climatic condition in the study location. These temporal variations which are prevalent within the country (Afangideh *et. al*., 2010) indicate uncertainty in climatic variables from year to year. Therefore performance of maize in the location will depend on the prevailing climatic conditions in a season (Adikuru *et. al*., 2020). However, within both seasons the pattern of rainfall was largely the same.

b) Maize vegetative growth response to season

Inter-annual variability in climatic conditions at the study location is confirmed by the significant differences in height (p=0.019), stem dry matter (p=0.015) and highly significant differences in leaf area (p=0.004) between 2009 and 2010 (Table 2). This is an indication of uncertainty in climatic variables from year to year (Adikuru *et. al*., 2020) and significant impact of climatic factors on maize development (Oluwaranti *et. al*., 2015). The difference in climatic factors between the years led to significant differences in maize vegetative growth. Hence, the effect of year x variety interaction was highly significant on height (p=0.003), number of leaves (p=0.001) and leaf area (p=0.003). Adikuru *et. al*., (2020) had reported that inter-annual variability in climatic factors only caused a minor year x variety interaction effect at the reproductive stage of maize development. This suggests that the effects of change in climatic factors are more significant on maize at the vegetative than the reproductive stage of development. This is due to the fact that moisture stress associated with climate change in the area occurs at the early vegetative stage of maize development. Furthermore, increase in soil moisture availability at the later stages, due to increase in rainfall, enables maize to recover from the adverse effect of moisture deficit at the early stages.

c) Effect of time of planting on maize vegetative growth

The effect of time of planting was highly significant (p=0.001) on all the parameters (Table 3). This must have resulted from the variation in available moisture determined by the prevailing rainfall and temperature conditions at the different time of planting. Across the planting months and in both years, total rainfall at the study site was lowest in February (65.8 and 36 mm) and highest in April (237.8 and 125.5 mm), while maximum temperature was generally the same. Consequently, moisture availability was lowest in February and highest in April most likely due to higher evapotranspiration in February when compared to April (Odjugo, 2010; Chineke *et. al*., 2011). Maize planted on March 30 did not differ significantly from maize planted on April 14 in all parameters except in leaf area where it grew significantly greater by 14.3%. Therefore during delayed onset of rain in this location, optimum vegetative development of maize can be achieved by delaying planting till about March 30.When compared with maize planted on February 28, maize planted on

March 30 had 125.9, 28.5, 190.2, 408.8 and 270.5 % increase in plant height, number of leaves, leaf area, stem and leaf dry matter respectively. This implies that moisture deficit caused a 55.7, 22.2 and 65.5 % reduction in height, number of leaves and leaf area respectively when maize was planted on February 28 compared to March 30. Accumulation of dry matter in stem and leaf was therefore reduced by 80.4 and 73.0 % respectively due to moisture deficit. Maize is affected directly and indirectly by moisture stress at all stages of development with the overall effect being the reduction in growth (Schussler and Westgate, 1991; Danquah *et. al*., 2001; Khan *et. al*., 2001; Anjum *et. al*., 2011). At the vegetative growth stage, reduction in plant height, stem diameter and leaf area with increasing water stress causes reduction in total biomass accumulation (Khan *et. al.,* 2001). Reduction in dry matter production when maize encounters water deficit is a result of decline in photosynthesis per plant. Decline in photosynthesis can be due to a reduction in light interception as leaf expansion is reduced or as leaves senesce, and to reduction in carbon fixation per unit leaf area as stomata closes or as photo-oxidation damages the photosynthetic mechanism (Bruce *et. al*., 2002).

d) Response of maize vegetative growth to poultry manure application

The effect of poultry manure application was highly significant ($p=0.001$) on all the parameters (Table 3). Maize height, number of leaves, leaf area, stem and leaf dry matter significantly increased by 106.2, 24.0, 159.0, 117.5 and 115.9 % respectively in response to 10 tons ha^{-1} of poultry manure. Similar result had been reported by Uduma and Eka (2006). Poultry manure improves soil organic matter, increases availability of exchangeable cations and thus enhances crop growth (Onwuka and Asawalam, 2006; Boateng *et. al*., 2006). Significant sowing date x poultry manure effect indicate that response of maize vegetative parameters to poultry manure application was highly dependent on time of planting (Iken and Amusa, 2004). It also showed that application of poultry manure reduced the impact of moisture deficit and led to improvement in height, number of leaves, leaf area, stem and leaf dry weight by 131.6, 44.2, 184.3, 211.4 and 215.8 % respectively after 42 days from planting. The greatest responses occurred when maize was planted on February 28 and April 14. This suggests that when maize is planted before the onset of rains, poultry manure could absorb the moderate moisture available in the soil and release same along with nutrients at dry moments. When the rains are established, the role of poultry manure basically becomes the supply of nutrient elements. Therefore poultry manure could play a dual role of supplying nutrient and moisture conservation (Ewulo *et. al*., 2008; Adeyemo and Agele, 2010). However, this study could not determine the extent to which each role contributed to the total effect on vegetative growth. The response of maize varieties to poultry manure application did not differ significantly in all the parameters except number of leaves ($p=0.002$), just as the effect of poultry manure on all the parameters except stem dry matter did not differ significantly between the years. The year x sowing date x poultry manure interaction was highly significant ($p=0.001$) on all the parameters except leaf dry matter. This shows that the effect of poultry manure neither depends on the variety of maize nor the year but in response to time of planting the effect of poultry manure depends on the year. The implication is that response of maize vegetative development to application of poultry manure (and perhaps other amendments) in the location depends on time of planting (Iken and Amusa, 2004). This may be attributed to differences in moisture availability at the different planting times since moisture is required for absorption and translocation of dissolved nutrients.

e) Varietal differences in vegetative growth of maize

Among the maize varieties, significant differences occurred in plant height ($p=0.016$) while highly significant differences ($p=0.001$) occurred in number of leaves and leaf area(Table 4). When compared with TZL COMP4 C3, the landrace OKA AWAKA grew taller by 14.7 % had 6.6 % more leaves and 21.7 % larger leaf area. Similarly, OKA AWAKA had 6.8 % more leaves and 20.1 % larger leaf area when compared with TZE COMP3 C3. There were no significant differences between TZE COMP3 C3 and TZL COMP4 C3 in all the parameters. According to Ngwuta*et. al.* (2015), maize landrace varieties planted in southeastern Nigeria are usually significantly taller than improved varieties and phenotypic variations among maize genotypes are attributable to genetic and environmental control. The effect of sowing date x variety interaction was significant on plant height ($p=0.012$) and highly significant on number of leaves ($p=0.002$), stem dry matter ($p=0.001$) and leaf dry matter ($p=0.001$). The year x sowing date x variety interaction was however, highly significant on only number of leaves ($p=0.001$). This indicates that the vegetative development of maize varieties depended largely on the time of planting but this response of maize varieties to time of planting did not depend on the year. Therefore, the maize varieties used in this study differed in their sensitivity to moisture deficit at the vegetative stage within a season and this effect was largely the same from season to season. This suggests the existence of variability for development of drought tolerant maize genotypes adaptable to the rainforest agroecology.

V. Conclusion

Moisture deficit occurs in Owerri southeast Nigeria at the early season when maize is at the early stage of vegetative development. As expected, vegetative development of maize was significantly reduced and this also led to reduction in dry matter accumulation. However, sensitivity to moisture deficit varied among maize varieties. Therefore exploitable variability exists for development of drought tolerant maize genotypes adaptable to the rainforest agroecology. From this study, we conclude that delaying planting and applying poultry manure for moisture conservation and nutrient supply are effective strategies to reduce the impact of moisture deficit on maize growth in the rainforest agroecology. Furthermore, landraces may be very important as genetic reservoir for the development of drought tolerant varieties in the region and therefore needs preservation.

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Table 1: Rainfall temperature and relative humidity in 2009 and 2010 at Owerri Nigeria

	Rainfall (mm)		Temperature (^{0}C)				Relative humidity (%)	
			2009		2010			
	2009	2010	Max.	Min.	Max.	Min.	2009	2010
January	39.4	33.0	34	15	37	17	76	72
February	65.8	36.0	35	14	36	19	78	71
March	81.5	36.2	35	15	36	19	76	70
April	237.8	125.5	35	14	37	18	80	76
May	250.2	382.0	34	15	30	18	79	77
June	208.9	207.7	36	17	38	19	80	78
July	486.3	86.1	33	18	39	19	87	80
August	485.9	318.4	33	18	39	18	89	83
September	558.1	382.2	32	20	39	18	79	80
October	207.2	398.8	37	21	39	18	83	79
November	111.8	108.6	35	21	39	19	76	78
December	0.0	0.0	35	21	39	17	71	75

Table 2: Analysis of Variance for maize vegetative parameters at 6 weeks after planting

Sources of variation	df	Height	No. of Leaves	Leaf Area	Stem Dry Matter	Leaf Dry Matter
Replication	2	339.10	0.71	162124.00	3.41	13.40
Year (Y)	1	1618.30*	2.56	2333984.00**	202.49*	53.89
Error a	2	32.20	0.42	8996.00	3.01	4.35
Sowing Date (SD)	3	11460.50**	28.15**	9223812.00**	184.75**	478.68**
Y x SD	3	1409.40	1.07	1994467.00**	44.76**	14.90
Error b	12	466.30	1.16	80194.00	2.62	6.75
Poultry Manure (PM)	1	40299.60**	68.89**	42670399.00**	155.79**	536.27**
Y x PM	1	4.40	0.05	6459.00	25.35**	1.52
SD x PM	3	3429.20**	2.25**	3779076.00**	32.65**	85.53**
Y x SD x PM	3	2184.60**	3.10**	275023.00**	8.25**	0.44
Error c	16	108.40	0.13	126918.00	0.89	2.37
Variety (V)	2	604.40*	2.92**	928142.00**	1.95	0.08
Y x V	2	884.60**	2.18**	717457.00**	2.12	5.69
SD x V	6	410.40*	0.93**	223388.00	4.31**	9.44**
PM x V	2	2.10	0.97*	184835.00	0.66	2.46
Y x SD x V	6	235.70	1.88**	80775.00	1.06	3.60
Y x PM x V	2	183.80	1.97**	405798.00*	0.91	2.07
SD x PM x V	6	131.20	0.67*	185144.00	1.06	3.56
Y x SD x PM x V	6	121.90	0.94**	203053.00	0.91	2.59
Error d	64	137.60	0.23	112337.00	0.76	2.20
Total	143					

** and * indicate significance at 1 and 5 % levels of probability respectively

Table 3: Effect of sowing date and poultry manure on maize vegetative parameters at 6 weeks after planting

Sowing Date	Poultry Manure	Height (cm)			No. of Leaves			Leaf Area (cm^2)			Stem Dry Matter (g)			Leaf Dry Matter (g)		
		0	10	Mean	0	10	Mean	0	10	Mean	0	10	Mean	0	10	Mean
FEB 28		17.79	41.20	29.49	4.43	6.39	5.41	312.00	887.00	599.00	0.44	1.37	0.90	1.14	3.60	2.37
MAR 15		31.44	42.40	36.92	5.78	6.60	6.19	819.00	1303.00	1061.00	0.60	0.99	0.79	1.42	2.30	1.86
MAR 30		42.64	90.61	66.62	6.14	7.76	6.95	941.00	2535.00	1738.00	3.41	5.74	4.58	6.76	10.81	8.78
APR 14		34.22	85.71	59.97	6.86	8.00	7.43	670.00	2371.00	1520.00	2.62	7.28	4.95	3.98	12.04	8.01
Mean		31.52	64.98		5.80	7.19		685.00	1774.00		1.77	3.85		3.33	7.19	
$LSD_{(Sowing\ date)(SD)}$		11.09			0.55			145.40			0.83			1.33		
$LSD_{(Poultry\ manure)(PM)}$		3.68			0.13			125.90			0.33			0.54		
$LSD_{(SD\ X\ PM)}$		11.90			0.57			219.80			0.92			1.48		

Table 4: Differences in vegetative parameters among maize varieties at 6 weeks after planting

Maize variety	Height (cm)	No. of Leaves	Leaf Area (cm^2)	Stem Dry Matter (g)	Leaf Dry Matter (g)
TZE COMP3C3	49.90	6.35	1157.00	3.04	5.25
TZL COMP4C3	44.18	6.36	1142.00	2.69	5.22
OKA AWAKA	50.67	6.78	1390.00	2.69	5.30
LSD	4.78	0.19	136.70	n.s	n.s