Plant Spacing, Dry Matter Accumulation and Yield of Local and Improved Maize Cultivars.

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Abstract: Field experiments were conducted at the Teaching and Research Farm, Federal University of Technology, Owerri, Nigeria to determine the influence of plant spacing on the yield and dry matter accumulation of local and improved maize varieties. The experiments were laid out as a split plot in a randomized complete block design (RCBD) with four replications consisting sixteen (16) treatments per replicate. The results obtained showed that maize growth and yield was significantly (P = 0.05) affected by the different plant spacing used. The highest dry maize grain yield was obtained in the hybrid varieties using plant spacing of 25 x 75cm while the lowest yield was obtained in the local maize type with plant spacing of 100 x 100cm. The trend observed in the other plant attributes measured such as the Mean Leaf Area (MLA)(cm^2), the plant height and the Dry Matter Accumulation (DMA) showed that the hybrid maize varieties performed significantly better than the local ones and had higher nutrient efficiency and conversion rate than the local cultivars although the yield was predicated on plant population. Based on the research findings, growing maize sole using plant spacing of 25 x 75cm remains the best recommendation for optimum maize grain yield in the field and an improvement of the local maize cultivars genetically for sustainability and food security purposes. [The Journal of American Science. 2008;4(1):11-19]. (ISSN: 1545-1003).

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Introduction

Maize (*Zea mays L.*) is a staple human food, a feed for livestock and raw material for many industrial products. It is an important food crop grown commercially in large scale and at subsistence level by many resource poor farmers. It matures earlier than most food crops and it is used in homes to prepare different dishes especially during the "hungry period" of June - July when most other crops had been planted by the farmers. Maize is a crop of world repute and has a remarkable adaptability in a wide range of climates, and it is more extensively distributed over the earth than any other local crops (Onwueme and Sinha, 1991). Great variations occur in the yields of maize and these large differences in yield cannot only be accounted for by climate or soil variability alone since areas with the same climate and rainfall pattern show markedly different average yields.

Ibeawuchi and Ofoh; (2000) reported that majority of our food is produced by the resource poor farmers, thus, among farmers in Southeastern Nigeria especially the resource poor ones there is an argument amongst this group of farmers on the yield, colour and taste of improved and local cultivars of maize. The resource poor farmers regard their local best (yellow or white) as being better than the improved ones. Most times differences may occur to a large extent due to cultivation techniques including use of fertilizers. However, our local maize is open pollinated while the improved ones are scientifically developed using several methods of guided cross-pollination. The most important thing about the improved maize variety is the development of improved inbreeds that would produce greater F_1 seed yield when hybridized.

Plant spacing is an important agronomic attribute since it is believed to have effects on light interception during which photosynthesis takes place which is the energy manufacturing medium using green parts of the plant. Also, it affects the photosphere and rhizosphere exploitation by the plants especially when spacing is inadequate and the plants suffers clustering together. Good plant spacing gives the right plant density, which is the number of plants, allowed on a given unit of land for optimum yield (Obi, 1991).

Despite the fact that a lot of research work had been carried out on maize by many agricultural scientists not much have been done in understanding the yield and dry matter accumulation of improved and local cultivars maize varieties with different endosperms in relation to different plant spacing. This gap in record and knowledge led to the initiation of this experiment on the effect of plant spacing on the yield and dry matter accumulation of local and improved maize cultivars with a view to proffering solution to the confused state of resource poor farmers as regards to local and improved maize cultivars cultivation.

Materials and methods

The experiment was conducted in 2003 and repeated in 2004 at the Teaching and Research Farm of Federal University of Technology, Owerri Nigeria (5^0 $27^/$ N and 7^0 $02^/$ E) on an elevation of 57.5m above sea level.

Meteorological data collected from Owerri Met. Centre showed that the environment had an annual rainfall of 2311.20mm and 2334.40mm in 2003 and 2004 cropping seasons respectively. It has a mean annual temperature of $31.^0$C and relative humidity of 89%.

Laboratory soil mechanical analysis showed that the soil had a sand value of 85%, silt 9.2% and clay fraction of 5.8% while the chemical soil analysis showed a pH of 4.92 (1 soil: 2.5 water), organic matter 1.98%, total nitrogen 0.08%, 9.88 ppm phosphorus Bray 2-P and exchangeable cations calcium, magnesium and potassium of 0.85, 0.55 and 0.51 Cmol $^{(+)}$kg^{-1}.

The experimental site was ploughed, harrowed and laid out as a split in a randomized complete block design with four treatments – (improved white and yellow maize and local white and yellow maize cultivars) using four spacing and were replicated 3 times giving a total of 48 plots.
The treatments include two local maize cultivars with yellow and white endosperms bought from Nkwo-ukwu Ihiagwa market and improved (hybrid) maize with yellow and white endosperm called Oba super obtained from the Imo State Agricultural Development Programme ADP, Okigwe Road Owerri. The maize cultivars were split into four spacing in a randomized complete block design.

The spacing used includes:		Plant population per hectare
25 x 75 cm	=	53,333 maize plants ha^{-1}
50 x 100cm	=	20,000 maize plants ha^{-1}
30 x 50cm	=	66,667 maize plants ha^{-1}
100 x 100cm	=	10,000 maize plants ha^{-1}

Each main plot measured 3 x 4m (12m^2) and this was split into 4 subplots measuring 1.25 x 1.75m with a 50cm gap between each subplot across the length and width of the sub plots. There was a 50cm gap between each block with a 1m-guard area round the experimental area, a total of 253.5m^2.

The four maize cultivars were planted in the field according to the spacing with two seeds per hole and weak later thinned down to one plant per hole 2 weeks after. The experimental plots were weeded two times at 4 and 8 weeks after planting (WAP). N: P: K 15:15:15 fertilizer was applied to the plots 5 weeks after planting at 400kgha^{-1} or 87.5g per subplot. Data were collected from 2 to 12 WAP

Data collected were on plant height (cm), Leaf Area (MLA)(cm^2) dry matter accumulation; (DMA) Francis *et al* (1969) and grain yield (t.ha^{-1}). Mean leaf area was determined using the formula by Ogoke *et al* (2003). Post harvest operations were carried out on the maize cob to obtain the grain. The grains were weighed with a weighting scale and appropriate records were taken.

Treatment effects were determined using analysis of variance (ANOVA) as described by Wahua (1999).

Results and Discussion

Results

Main effects of plant spacing on selected growth parameters of the Hybrid and local maize cultivars at 2,4,6,8 and 10 WAP.

Plant Height

There were variations observed in plant height of the improved and local maize cultivars. The local maize also varied in heights between the local yellow and white cultivars being significantly different from the hybrid maize cultivars.

Within the hybrids, the heights were not significant except hybrid white at 6 WAP that showed significant different amongs the maize plants but this disappeared at 8 and 10 WAP showing that they are genetically improved. However, the local maize cultivars yellow and white, with spacing 30x50cm and 25x75cm had significantly taller maize plants than those spaced 50x100cm and 100x100cm. They were also significantly taller than the hybrids yellow or white.

Mean Leaf Area (MLA) (cm^2)

There was an increase in mean leaf area from 8 to 10 WAP for both the hybrid and the local maize types in all the different plant spacings used (Table 2). Plant spacing of 100 x 100 and 50 x 100cm largest mean leaf area had the for both the hybrid and were maize types land race while plant spacing had the least MLA. Significantly different from maize plants with 25 x 75cm and 30 x 50 cm respectively (Table 2)

Dry Matter Accumulation (DMA)

The dry matter accumulation of the maize cultivars is presented in Table 3 at 6, 9 and 12 WAP and the results indicate that the different plant spacing influenced biomass accumulation. Plant spacing 100 x 100cm, 50 x 100 and had the highest above ground biomass at taselling and silking for the hybrid and the local maize cultivars while plant spacing 30 x 50cm had the least biomass in both cultivars.

Maize Yields and Monetary Value

Results presented Table 4 are the grain yield and the corresponding monetary value of the different maize cultivars. The table shows that maize grain yield was greatly influenced by the different plant spacing used. In both the hybrid and the local types, plant spacing 25 x 75cm with plant density of 53,333 plants/ha had the highest grain yield closely followed by plant spacing 30 x 50cm that had 66,667 plants/ha while plant spacing 100 x 100cm with plant density of 10,000 plants/ha had the least grain yield. The same trend was also observed in terms of the monetary value. Plant spacing 25 x 75cm with grain yield of 3/ha had the highest monetary value of N63, 000.00 (white endosperm), while plant spacing 100 x 100cm and 50 x 100cm with grain yield of 1.1/ha and 1.20/ha respectively had least monetary value of N25, 000.00.

Discussion

The yield of a crop is a function of a number of factors and processes such as light intercepted by the canopy, metabolic efficiency of plants, translocation efficiency of photosynthates from leaves to economic parts and sink capacity or sink strength amongst others (Doku, 1977) and the genetic make up of the crops. Also, it is recognized that the photosynthetic capacity of the plant determines the overall productivity; the extent of development of each yield character is also dependent on the interrelationship between the various yield components. More so, consideration must be given to the microenvironment, which supports the growth and yield of the plant and translocation efficiency and conversion rate of the plant.

Different plant spacing with different plant densities generally influenced maize plant height. The 50 x 100cm and 100 x 100 plant spacing thus followed the observed trend in the plant heights in which the local cultivars with plant spacing of 25 x 75 cm and 30 x 50 cm had the tallest plant height at 10 WAP. The plant spacing, for hybrid maize plant, which had the least plant, height could be explained by the competition for scarce growth resources available, the genetic makeup and environmental factors of the plant. It means that these identified factor could be harnessed especially close spacing which cause competition and removal of nutrients for growth and genetic makeup either for tallest or shortness for the particular plant.

The increasing trend observed in leaf canopy cover and leaf area is evidence of good photosynthates assimilation, which resulted in higher vegetative growths. Plant spacing 25 x 75cm (hybrids) allows the maize leaves to capture enough sunlight and other resources, which subsequently was converted into more vegetative growth resulting in higher grain yield due to high metabolic efficiency and conversion rate of the hybrid plants. A plant forms adequate number of leaves and branches when it has adequate supplies of light, nutrients and water. Plant spacing 100 x 100cm had the highest mean leaf area at 8 and 10 WAP (Table 2), thus more solar radiation were absorbed and used for photosynthesis. Because of the improved nature of the hybrid cultivars, they were genetically more advanced and enhanced to take up plant nutrients from the soil faster than the local ones coupled with high densities, which always give room for competition for light energy. The reduction observed in maize dry matter accumulation in plant spacing 30 x 50cm at the 9 WAP in both the local and the improved cultivars may be as a result of competition for nutrients and other growth factors. This points to the fact that closer spacing in a cropped field, may lead to greater reduction in dry matter accumulation as a result of competition. Earlier reports of Makinde and Alabi (2002), and Sterner (1984) support this observation. Therefore, it is not surprise as closely spaced plants compete for nutrient and other growth factors, they tend to grow taller than those with wider spacing. This fact is evident in this experiment.

A given plant population may be arranged in several ways, leading to variation in intensity of interaction between the cultivars concerned. The supply of growth factors such as light, water and nutrients to plants is affected by the interaction between the plants and thus, efficiency of the use of the limiting resources (Martin and Snaydon, 1982). This fact has to be further investigated for an intercropping system considering the number of crop combinations in an intercropped field.

Maize leaf area was not significantly affected by the plant spacing. Maize plants with wider spacing had higher leaf area than those with closer spacing 100 x 100cm spacing has significantly higher leaf areas and heavier seed weight per a thousand seed weight than the others with closer spacing in this experiment. This indicates photosynthetically higher production and may serve as prediction tool for crop growth and yield. This may be misleading since many factors govern yield of any crop. The primary production outlook may be determined if the leaf area is considered over the land area upon which the crop is produced. A higher lead area correspond to higher lead mass and these shows that there will be higher respiration rate of the maize crop (Table 2)

Maize grain yield was significantly affected by the different plant spacing with the hybrid varieties yielding more than the local maize variety. Evans (1993) had earlier stated that, although no single process holds the key to greater crop yield, physiological comparison between older and newer higher yielding varieties have often been used to identify characteristics that may have contributed to crop improvement. From the study conducted by Ding Kuhu *et al* (1991), the longer a crop is able to grow in the particular site in a season, the greater is its biomass production in that site. Thus, increase in biomass production with longer duration of growth reflects not only the opportunity for more prolonged interception of photo synthetically active radiation by the crop, but also the greater opportunity for uptake of nitrogen and other nutrients especially in low input condition (Yoshida, 1993). It is however, noted that for grain crops, grain yield will often increase with duration up to a certain point but what happens beyond that point depends on environmental and agronomic conditions (Evans, 1993). From this experiment, hybrid yellow and white with 25 x 75 cm spacing had higher yield than the other hybrids but were not statistically significant. However, there were statistically significant yields difference between the hybrid yellow and white and the local maize cultivars yellow and white. The hybrids yielded higher than the local cultivars in all spacing used. For the 1000 seed weight, the hybrid and local maize cultivars yellow and white with 100x100cm spacing had higher weight per 1000 seed than other spacing either of hybrid or local maize cultivars. According to Standhill (1981), crop physiologists have established that the increased solar interception achieved by the large and larger living crop canopies can largely explain the high yield levels in modern crop production by the adapted cultivars. From this experiment the genetic composition of the two maize cultivars came into play as the more genetically improved ones performed better in total yield than the yet to be improved local maize cultivars. It could be that the 25x75cm spacing had higher maize grain yield by number and not by weight while maize plant with 30c50cm spacing were higher in density but produced grains with light weight whereas the 100x100 cm spacing had higher 1000 maize grain weight than all of other treatments in the experiment.

Conclusion

Adequate plant spacing coupled with plant population per unit area gives a good yield. However, the experiment observed that high dry matter accumulation without improved genes to metabolize the products of photosynthesis as in the case of local maize cultivars leads to low crop yield. Further research is recommended for plant spacing and the numbers of maize seeds per hill say, 1,2,3, or4 maize. Seed per hill with a new to understanding their performance as sole since most resources poor farmers use this system in their multiple cropping systems. Farmers and maize growers should be encouraged not only to use proper plant spacing but also to grow hybrid maize varieties since these perform far better than the unimproved local land maize types.

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References

1. Ding Kuhu, M.H.F. Schnier, S.K. Datta, K. Dorffling and C. Jahellana 1991. Relationships between ripening phase productivity and crop production, canopy photosynthesis and senesce in transplanted and direct seeded lowland rice. Field crops Res. 26. 237 – 345.
2. Doku, E.V. 1977 Some concepts of Crop yield. Ghana Journal of Agric Sc. 10 (1), 53 – 60.
3. Evans, L.T. 1993. Crop evolution, adaptation and yield. Cambridge Univ. Press. 500 pp.
4. Francis *et al* (1969) In Ogoke, I. J. Egesi, C.N. and Obiefuna J. C. (2003). A review of some non destruction linea measurement procedures for leaf area determination in crops International Journal of Agriculture and rural Development, 4: 74-80.
5. Ibeawuchi, I.I. and Ofoh, M.C. (2000) Productivity of Maize/Cassava/Food Legume mixtures in South Eastern Nigeria (J. Agric & Rural Dev. 2000) 1 (i) 1 - 9
6. Makinde, E.A. and B.S. Alabi 2002. Influence of spatial arrangement on the growth and yield of maize – melon intercrop. Moor Journal of Agricultural Research 3: 59 – 63.
7. Martin, M.P and R.W. Snaydon 1982. Intercropping barley and beans. I: effects of planting pattern. Experimental Agriculture 19: 139 – 148.
8. Obi I.U 1991 Maize, its agronomy, diseases, pests and food values. Optional Computer Solutions Ltd., Enugu Pp 207.
9. Onwueme I.C. and T.D. Sinha 1991 Field Crop Production in Tropical Africa CTA. Ede. The Netherlands Pp. 159 – 175.
10. Standhill, C. 1981. Efficiency of water, solar energy and fuel use in crop production In: physiological processes limiting plant productivity. C.B. Johnson, Baternthes, London Pp. 39 – 51.
11. Sterner, K.G. 1984. Intercropping in tropical smallholder agriculture with special reference to West Africa. Schriftenreiheder GT2. No. 137 West Germany, Pp 312.
12. Wahna T.A.T 1999 Applied Statistics for Scientific Studies. Afrika-Link books, Owerri. Pp. 129 – 157.
13. Yoshida S. 1993. Rice In: IRRI (ed). Potential Productivity of field crops under Different Environment. IRRI, Los Banos. Philippines. Substitute

Table 1: Effects of plant spacing on plant height (cm) of the improved and local maize cultivars at 2,4,6,8 and 10 WAP

	Hybrid maize										Local maize									
	Yellow endosperm					White endosperm					Yellow endosperm					White endosperm				
	Sampling time (WAP)										Sampling time (WAP)									
Plant spacing (cm)	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
25 x 75 (Ps_1)	15	28	37	84	132	17	37	58	97	150	10	38	47	75	180	11	39	53	87	199
50 x 100 (Ps_2)	16	30	43	79	128	19	37	47	90	101	13	35	42	81	169	12	29	44	93	174
30 x 50 (Ps_3)	12	35	42	82	130	18	30	38	90	125	12	34	33	70	182	18	20	38	86	198
100 x 100 (Ps_4)	18	24	34	83	120	15	28	38	84	129	14	24	32	88	160	16	24	40	89	171
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	3.31	NS	NS	NS	NS	NS	NS	2.25	NS	NS	NS	NS	2.70

Table 2: Effects of plant spacing on mean leaf area (cm^2) of the improved and local maize cultivars at 2,4,6,8, and 10 WAP

	Hybrid Yellow endosperm					White endosperm					Local land race Yellow endosperm					White endosperm				
	Sampling time (WAP)										Sampling time (WAP)									
Plant spacing (cm)	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
25 x 75 (Ps_1)	5	7	10	26	40	9	10	12	18	40	2	8	20	28	49	4	8	16	20	36
50 x 100 (Ps_2)	4	8	11	19	36	7	10	21	33	55	3	10	17	20	63	3	5	16	28	36
30 x 50 (Ps_3)	6	7	12	17	25	5	9	11	16	34	2	10	16	23	47	2	6	18	29	39
100 x 100 (Ps_4)	4	6	17	36	59	4	17	20	42	60	2	10	18	19	101	3	5	18	22	87
LSD(0.05)	NS	NS	NS	NS	4.22	NS	NS	NS	3.57	5.88	NS	NS	NS	NS	2.94	NS	NS	NS	NS	4.6

Table 3: Effects of plant spacing on dry matter accumulation (Dm)(g) of the improved and local cultivars at 6,9 and 12 WAP

	Hybrid						Local land race					
	Yellow			White			Yellow			White		
	Sampling time (WAP)						Sampling time (WAP)					
Plant spacing (cm)	6	9	12	6	9	12	6	9	12	6	9	12
25 X 75	900	1500	1900	800	1790	1800	600	950	1909	670	980	1860
50 X 100	700	990	1890	680	890	1790	50	790	1829	600	960	859
30 X 50	690	65	1009	760	770	1060	700	780	1290	574	684	1090
100 X 100	690	900	1880	760	790	1790	500	540	1725	438	890	1894
LSD (0.05)	5.50	12.75	24.63	17.40	20.66	22.55	19.73	22.39	21.97	16.55	22.65	20.45

Table 4: Grain Yield (tons/ha) and monetary value (N) of the improved and local cultivars using different plant spacings

	Hybrid						Local land race					
Plant spacing (cm)	Yellow t/ha Endosperm		Monetary Value (N)	White t/ha endosperm		Monetary Value (N)	Yellow t/ha Endosperm		Monetary Value (N)	White t/ha endosperm		Monetary Value (N)
25 x 75	2.80	78	765352	3.00	68	742500	1.89	65	453600	1.90	61	414231.30
50 X 100	2.50	81	683350	2.10	70	519750	1.20	66	288000	1.20	60	263004.00
30 X 50	2.75	58	751685	2.60	54	643500	1.75	50	420000	1.30	48	284921.00
100 X 100	2.10	98	574014	2.00	95	495000	1.16	95	278400	1.08	90	236703.60
LSD (0.05)	NS	5.81		1.12	6.25		NS	7.22		NS	9.30	

	local: white:	yellow	Hybrid white	yellow
Mean market surveys 2003				
Ekeukwu Owerri (main market)	210	230	250	280
Afor Enyiogugu market	200	210	230	250
Relief market Owerri	220	250	230	250
	N210	N230	N236.67k	N260
Mean market surveys 2004				
Ekeukwu Owerri	230	260	265	310
Afor Enyiogwugwu market	220	240	250	260
Relief market Owerri	235	250	260	290
	N228.33	N250	N258.33	N286.67
Mean price per kg =	N219.17,	N240.00	N247.50,	N273.34