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Comparison of Growth and Yield Components of Five Quality Protein Maize Varieties

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Abstract Field trials were conducted during 2010 and 2011 maize cropping seasons to compare the yield and evaluate the relationship that exist among various growth and yield components that contribute to grain yield in quality protein maize (QPM). Five QPM varieties were planted in a randomized complete block design in three replicates in Ibadan. The result obtained showed that years, variety and years of evaluation interaction were not significantly different, however varieties differed significantly in 50% days to flowering, harvest field weight and number of kernel per cob ($P<0.05$), leaf area, ear length and weight of 1000 grains ($P<0.01$), plant height and grain yield ha^{-1} ($P<0.001$). ART98-SW5OB and Obatanpa were superior in almost all the agronomic traits evaluated while ART98-SW6 OB was least in plant height and produce flowers earlier than the other varieties. Grain yield showed a strong significant positive correlation with plant height, and low positive correlation with the other agronomic traits. Days to 50% flowering and number of kernel per cob were negatively associated with grain yield. Ear length correlated positively and strongly with plant height and number of kernels per cob ($P<0.001$). Indirect selection for secondary yield traits that correlate positively with primary yield components is fundamental to the overall grain yield improvement processes in QPM. Plant height, flowering days and ear length were important agronomical trait determining grain yield in this study and could be considered among other agronomic traits during selection process while breeding for increased grain yield in Quality protein maize.

Keywords Days to 50% flowering, Ear length, Grain yield, Plant height, and Quality protein maize

1. Introduction

Maize (Zea mays L.) is an important crop in many parts of the developing world. It occupies the third place after wheat and rice[6]. Maize is the most extensively distributed cereal crop been adapted to a wide range of environments[20]. It is a strategic crop in many parts of the developing world where livelihoods of millions of resource poor farmers depend on maize cultivation[28]. The acceptability of this commodity has been genetically improved by the development of Quality Protein Maize (QPM) with improved nutritional quality which combines opaque-2-gene high lysine with tryptophan[5, 29].

QPM has superior nutritional value compared to non QPM and other cereals[18]. This nutritional quality has been described to be capable of improving the nutrition and livelihood of the poor[4]. Grain yield development in maize is dependent on the direct or indirect contributions of various agronomic traits such as: days to tasselling, days to silking, tassel branches, plant height, ear height, leaf length, leaf width, leaf area, ear weight, grain moisture, kernel number per row and 1000 kernel weight. These contributions had been reported by several authors. Leaf growth is an important component influencing light interception, crop growth and yield in cereals[7]. Final yield of dry matter has been shown to be proportional to the total amount of radiation intercepted by crop during the growth period[24]. Plant height, cob length, ear height, number of rows per cob, number of kernel per cob, weight of 1000 kernels were observed to have positive correlation with grain yield[14].

Genetic and inconsistent environmental conditions are main factors influencing grain yield development and usually made direct selection for yield to be difficult[26]. However, inferences from correlation coefficient analysis are important useful tool in selection of several traits simultaneously influencing yield[16]. Growth and yield traits in maize are often linked or associated with each other. Hence genetic correlations between agronomic traits and secondary traits can be used to improve primary ones that are poorly inherited or cannot be measured easily[15].

The objective of this study was to evaluate the relationship existing among various yield components of five Q P M varieties and to establish how these components contribute to grain yield.

2. Materials and Methods

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Five open pollinated QPM varieties (ART98-Sw5OB, ART98-Sw6 OB, Tzpb, Ile1 ob and Obatanpa) were planted in 2010 and 2011 maize cropping seasons at the Institute of Agricultural Research and Training, Ibadan, Nigeria. Land preparation was done mechanically by ploughing, harrowing, ridging. Soil physico-chemical analysis indicated that the Soil pH was 6.09%, Organic matter 1.33%, Organic N 0.096 and P (ppm) 7.36, Sand 75.9 % Silt 15.5% and Clay 7.8%. Seeds were sown at two seeds per hill at spacing of 75 x 50 cm in six rows of plot area size of 4.5 x 4m to obtained plant population of 53,333 stands per hectare.

Design: Design was a randomized complete block design (RCBD) with three replicates. N.P.K fertilizer was applied 2 weeks after planting and urea was applied 2 weeks to tasselling at the rate of 100 kg ha^{-1}. Weed was controlled using pre emergence herbicides and later by rogueing. The dry maize cobs were harvested and shelled after sun drying and grain yield taken after adjustment to 12 % moisture levels.

Data taken: Growth and yield data were taken on five selected and tagged plants of the two middle rows. These include days to 50% tasseling, plant height (taken with meter rule from the base of the plant to the tip of the tassel), ear height, leaf area (obtained by the formula, Leaf Area = L x B x 0.25[17] Where L = length of leaf and broadest width of the leaf, harvest field weight per plot at (22% moisture level) kernel number per cob, cob length, 1000 kernel weight and total grain yield per hectare.

Data Analysis: Data collected were analyzed using SAS version 8 to compute analysis of variance (ANOVA) and significant differences were determined at probability levels of 5, 1 and 0.1%. Significant interactive means were separated using standard error at P<0.05, while differences in character means were determined at P<0.05 using the least significant difference. Average correlation among the agronomic traits was obtained using Pearson Correlation Coefficients.

3. Results

Table 1 presents the summary of the analysis of variance of the agronomic traits of the five maize varieties. The performances of the varieties across the replicates varied significantly for days to 50% flowering, leaf area, number of kernel per cob (P<0.01), plant height, ear height and ear length(P<0.05) and weight of 1000 grains(P<0.001). Years of evaluation had no significant influence on all the agronomical parameters. Varieties varied significantly for days to 50% flowering, plant height, grain yield (P<0.001), ear length, weight of 1000 grains, leaf area, numbers of kernel per cob and harvest field weight (P<0.05). Years of evaluation and variety interaction were not significant for all the agronomical parameters.

Table 2 indicates the mean square values for the five evaluated maize varieties. TZPB and Obatanpa had the highest days of 54.50 and 55.16 to 50% flowering and were not significantly different from each other while ART98-Sw6OB flowered earlier with 52.33 days. ART98-Sw5 OB and Obatanpa had the highest height of 185.16 cm and 177.50cm respectively and were not significantly different from each other while ART98-Sw6 OB had the lowest height of 144.66cm. ART98-Sw5OB had the highest ear height of 69.6cm while ART98-Sw6OB and Obatanpa had the lowest ear placement and were not significantly different from each other. ART98-Sw5OB and TZPB had the highest number of leaves of 13.61 and 13.00 per plant respectively and were not significantly different from each other while Ile1ob had the least value of 12.16 leaves. Ile1ob, ART98-Sw5OB and Obatanpa had the highest values of 606.04 cm^2, 612.07 cm^2 and 571.81 cm^2 respectively and were not significantly different while Tzpb had the least value of 511.42 cm^2.

Ile1ob and Obatanpa had maximum ear length of 14.60cm and 14.80cm and were not significantly different from each other while ARTSw6OB had the shortest ear length of 12.88cm.

Ile 1ob had the highest field weight of 3.5 kg ha^{-1} while Obatanpa had the least value 2.63kg ha^{-1}. Obatanpa was superior in number of kernels per cob (418.67) while ART98-SW6OB was least with 351.33 kernels. Weight of 1000 grains differed significantly among the varieties (Table 1). Obatanpa had the highest 1000 grain weight of 332.05g while Tzpb had the least weight of 298.06. ART98-SW5OB had highest grain yield of 9.19 t ha^{-1} while Ile 1ob was least with 7.14 t ha^{-1}.

Table 1. Mean squares (MS) values of Growth and Yield components of five Quality protein maize varieties grown in 2010 and 2011 in Ibadan

Source of variation	DF	DYF	PLH	EHT	LA	K/C	ELT	FW	1000GW	GY
Rep	2	6.83**	775.03*	363.6*	16412.3**	7927.15**	2.67*	0.097	1896.67***	0.100
Years (Y)	1	1.63	8.53	27.07	0.00	791.5	0.00	0.00	197.63	0.5
Varieties (V)	4	7.91***	1588.21***	134.00	9927.86*	4571.07*	3.73**	0.88*	1029**	4.27***
YxV	4	0.21	3.95	10.15	0.00	367	0.00	0.00	30.86	0.28
Error	18	1.05	173.03	73.47	2156	2156	0.59	0.21	168.34	0.4
Total	29									

* ** *** denote effects significant at 5, 1 and 0.1 percent probability levels respectively

Table 2. Mean square (MS) values for growth and yield components traits of five maize varieties grown in Ibadan

Variety	DYF	PLH (cm)	EHT (cm)	No LVS	LA(cm^2)	K/C	ELT (cm)	FW(kg)	1000GW (g)	GY (t/ha)
Ile-1OB	54.16^{ab}	174.00^{ab}	59.33^{ab}	12.16^{b}	606.04^{a}	405.37^{ab}	14.60^{a}	3.53^{a}	302.88^{bc}	7.14^{c}
ART98 SW 5OB	53.00^{bc}	185.16^{a}	69.60^{a}	13.16^{a}	612.07^{a}	366.95^{bc}	14.06^{ab}	3.38^{ab}	314.63^{b}	9.19^{a}
ART98 SW6 OB	52.33^{c}	144.66^{c}	59.00^{b}	12.83^{ab}	558.40^{ab}	351.33^{c}	12.88^{c}	2.84^{bc}	312.53^{bc}	7.22^{bc}
TZPB	54.50^{a}	158.33^{bc}	64.00^{ab}	13.00^{a}	511.42^{b}	378.40^{bc}	13.51^{bc}	2.88^{bc}	298.06^{c}	7.48^{bc}
Obatanpa	55.16^{a}	177.500^{a}	58.70^{b}	12.50^{ab}	571.81^{a}	418.67^{a}	14.80^{a}	2.63^{c}	332.05^{a}	8.00^{b}
L.S.D $_{(0.05)}$	1.24	15.95	10.39	0.78	56.32	38.47	0.93	0.56	15.73	0.81

Values with same alphabets down the columns are not significantly different at $P\leq0.05$
DYF=50% days to Tasselling, PLH=plant height, EHT= Ear height, No LVS=number of leaves, LA= Leaf area, K/C=Kernel per Cob, ELT= Ear length, FWT= Harvest fresh weight, 1000 GW= Weight of 1000 Grains and GY= Grain yield.

Table 3. Correlation among various growth and yield traits of five Quality protein maize varieties

Trait	DYF	EHT	PHT	FWT	K/Cob	ELT	No LVS	LA	1000GW
EHT	0.03								
PHT	0.46*	0.23							
FWT	-0.18	0.13	0.35						
K/Cob	0.57**	-0.40*	0.34	-0.15					
ELT	0.46*	-0.23	0.60***	0.00	0.70***				
NoL	-0.09	0.50**	0.23	0.01	-0.43*	-0.38*			
LA	-0.20	0.18	0.08	0.53**	0.06	0.18	-0.44*		
1000GW	-0.05	-0.18	-0.05	0.06	0.23	0.00	0.28	0.53**	
GY	-0.03	0.25	0.54**	0.12	-0.05	0.15	0.04	0.33	0.14

* ** *** denote effects significant at 5, 1 and 0.1 percent probability levels respectively.
DYF= Days to 50% flowering, PHT=plant height, EHT= Ear height, NOLVS=number of leaves and LA= Leaf area, K/C=Kernel per cob, ELT= Ear length, FWT= Harvest fresh weight, 1000 GW= weight of 1000 grains and GY= Grain yield.

Table 3 presents the correlations among the various agronomical traits of this study. Days to 50% flowerings was significantly and positively correlated with plant height, ear length and number of kernel per cob, but it was positively but non significantly associated with ear height but non significant and negatively associated with leaf area, number of leaves, 1000 grain weight and grain yield. It was however negatively correlated with grain yield.

Plant height correlated positively though non significantly with ear height, harvest field weight, number of kernel per cob, ear length, leaf area and number of leaves per plant but negatively correlated with weight of 1000 grains.

Ear height correlated positively though non significantly with, harvest field weight, leaf area and grain yield. Ear height correlated significantly and positively with number of leaves per plant and non significantly but negatively with 1000 grain weight, but significantly negatively correlated with number of kernel per cob.

The number of leaves produced per plant correlated positively and non significantly with plant height and field weight. It however correlated significantly negatively with number of kernel per cob and ear length.

Leaf area was significantly and positively correlated with field weight and non significantly with ear height, plant height, number of kernel per cob and ear length but negatively correlated with 50% days to flowering and significantly negatively correlated with number of leaves per plant.

In this study ear length was strongly and positively associated with plant height and number of kernels per cob.

Ear length correlated positively though non significantly with leaf area, 1000 kernel weight and grain yield. Ear length was strongly and positively associated with plant height and number of kernels per cob it however correlated positively though non significantly with leaf area.

Harvest fresh weight was significantly positively correlated with leaf area and non significantly but positively correlated with 1000 kernel weight, grain yield, number of leaves per plant, ear length, ear height and plant height.

Number of kernel per cob correlated positively with ear length, and non significantly with leaf area and 1000 grain weight. However kernel per cob correlated negatively with number of leaves per plant and grain yield. Weight of 1000 grains weight was significantly positively correlated with leaf area but non significantly but positively correlated with field weight, number of kernel per cob, ear length, number of leaves per plant and grain yield.

4. Discussion

Identification of various growth and yield components and their relationship with grain yield in maize would assist breeders in the selection and development of superior QPM varieties for the farmers. Five QPM varieties were evaluated for growth and yield traits as they contribute to grain yield development. The result of this study showed that the varieties differed significantly in plant height, days to 50% flowering, ear length, leaf area, ear height, field weight, weight of 100 grains and grain yield. Variation in plant height could be attributed to differences existing in the genetic composition of the maize varieties[1]. Plant height correlated positively with harvest field weight, number of kernel per cob, ear length, leaf area and number of leaves per plant, days to 50% flowering and grain yield, this findings agreed with the earlier report of[3;13;19] inconsistency in referencing. Increased plant height provides more green area for increased photosynthetic activities and assimilates needed for grain filling[10]. The length of vegetative phase and dry matter yield in maize has been reported to be positively associated with the size of the plant as taller hybrids produce higher dry matter. Nevertheless, the rate of translocation of assimilates to the kernels of shorter hybrids were found to be greater than those of taller ones[2]. Positive association was observed between plant height and days to 50% flowering, this agreed with the earlier findings[27] who reported that internode extension terminates at floral initiation as early flowering maize genotypes are usually characterized with short plant heights. Ear height correlated positively with plant height, harvest field weight, leaf area, number of leaves per plant and grain yield[11; 22]. It was however negatively correlated with 1000 grain weight and number of kernel per cob[21]. Ear height is an important yield determinant feature in maize, the higher the ear height the more the number of ears that can develop from the nodes beneath. Leaf area correlated positively with field weight, ear height, plant height, number of kernel per cob, ear length and grain yield but negatively correlated with 50% days to flowering and number of leaves per plant. Higher leaf surface intercepts more light and efficient photosynthetic system which played vital role in the development of lengthy cobs[7]. Ear length was positively associated with plant height, number of kernels per cob, leaf area, 1000 kernel weight and grain yield but correlated negatively with ear height and number of leaves per plant, this findings agreed with the earlier report of[12; 21, 25]. Harvest fresh weight showed positive correlation with leaf area, 1000 kernel weight, grain yield, number of leaves per plant, ear length, ear height and plant height this findings agreed with the earlier report of[9]. Number of kernel per cob correlated negatively with number of leaves per plant and grain yield in this study, this report however contradicts earlier findings [23].

5. Conclusions

Plant height is a very important growth trait determining grain yield because of its strong positive association with grain yield in this study. It is also of importance to note that shorter maize varieties flower earlier than the tall QPM varieties and were also characterized with shorter ears. ART98-Sw5OB and Obatanpa were superior in grain yield and in most of the traits evaluated while Ile 1ob had lowest grain yield. Indirect selection for yield traits such as plant height, ear length and late flowering days genotypes among others would enhance increased grain yield in QPM.

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