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CONTRIBUTIONS OF SOME SELECTED GROWTH AND YIELD ATTRIBUTES TO GRAIN YIELD OF EXTRA-EARLY MAIZE IN SEMI-ARID ZONE, NIGERIA

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ABSTRACT
Contributions of some selected growth and yield attributes of extra-early maize (95TZEE-Y_1) variety to grain yield using correlation and path analyses were determined from the data obtained from a field experiment conducted to determined the response of this variety to rates of NPK (0, 40:20:20, 80:40:40 and 120:60:60 kg N:P_2O_5:K_2O ha^{-1}) and residual farm yard manure (0, 5, 10 and 15 t ha^{-1} applied to chilli pepper the previous season). All the parameters measured significantly related to grain yield except numbers of grain rows per cob and leaves per plant in 2005 and number of grain rows in 2006 and the combined that were not significant. 100-grain weight in 2005 and the combined and husked cob weight in 2006 had the greatest effect on grain yield and therefore made the highest percent contribution in which the share for 100-grain weight was 25% in 2005 and 27% when the two years data were combined while husked cob weight made the highest individual contribution of 32% in 2006 season. The percent contributions that otherwise could not be explained were generally less than 20% for both seasons and the combined; with the combined having the least value of 13%

KEY WORDS: maize, grain yield, yield attributes, NPK, residual FYM

INTRODUCTION
Maize is one of the major staple food crops in the Northern Guinea savanna since the yield obtained in this area is much higher than that of the forest zone where it was first cultivated in the country. The crop in Nigeria is mostly grown for its dry seeds or green cobs. However, there few large scale farm that grow the crop for use as animal feed. The superiority of the NGS is mostly attributed to the production more ears per plant (Iken and Amusa, 2004). However, as a result of development of early maturing materials, the cultivation of the crop is now fast extending to areas with shorter rainy season as found in the Sudan savanna. The reason for the wide adoption of the crop in this area is mainly due to the fact that it produces more yield than the local and more adaptable crops like sorghum and millet. For good growth and high yield, the maize plant must be supplied with adequate organic matter and other soil nutrients particularly nitrogen, phosphorus and potassium. The quantity required of these nutrients particularly nitrogen depends on the pre clearing vegetation, organic matter content, tillage method and light intensity among others (Iken and Amusa, 2004).
Farmers have realised that the new early maize materials though with smaller cobs, grain and stature can produce as good yield as the medium or late maturing maize varieties. This they attribute to production of more filled cobs when compared to the late types. Breeding work is seriously going on to improve the crop yield and resistance to pests and diseases. Thus, studies have been conducted to find out the contributions of both growth and yield attributes of many crops including maize to the final economic yield through the use of correlation and path analysis (Jaliya *et al.,* 2005; Sharifai *et al.,* 2006; Babaji *et al.,* 2005; Babaji *et al.,* 2006; Abubakar and Suberu, 2006). The findings of these works have come up with many positive recommendations toward enhancing both the quantitative and qualitative attributes of these crops. This work is therefore undertaken to find out the degree of associations among some selected growth and yield attributes of a newly introduced maize variety (95TZEE-Y_1) as well as determine their contributions to the final grain yield.

MATERIALS AND METHODS
Field experiment was conducted during the rainy season of 2005 and 2006 at the research farm of Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru (11^o 11'N, 07^o 38'E, 686m above sea level), Zaria, Nigeria to evaluate the response of extra-early maize variety to residual farmyard manure and current season applied NPK fertilizer. Different location was used for the different seasons. Each experiment previous one conducted in 2004 and 2005 to study the response of chilli pepper to four rates of FYM (0, 5, 10 and 15 t ha^{-1}). In each of the following season four rates of NPK (0:0:0, 40:20:20, 80:40:40 and 120:60:60 kg ha^{-1}) were randomly allocated main plot. The experiment was arranged in a split-plot design with three replicates. The gross and net plot sizes were 9m^2 and 3m^2, respectively. An extra-early maize variety 95TZEE Y_1 sourced from IAR seed unit was used. It is an extra-early maturing variety that matures in 75 days, resistant to foliar diseases but susceptible to Striga and therefore suitable for low rainfall areas. The

variety has white flint and is open pollinated. Information from IAR meteorological data station revealed that a total of 527mm and 757 were received during the growing periods in 2005 and 2006 season, respectively. Temperature varied from 18 to 33°C for the two seasons.

The land was sprayed with 2l/ha of glyphosate (360 Isopropylamine salt) herbicide which controlled weeds. Two weeks later, three seeds were sown per hole spaced 25cm and 75cm between stand and ridge, respectively. The plants were later thinned to 2 per stand given approximately plant population of 106, 600 plants/ha. The experiment was established on July 17th of each of the season. NPK fertilizer 20-10-10 was used and applied in two equal split doses at 1 and 4 weeks after sowing (WAS). Weeds were controlled through manual weeding at 3 WAS and during earth-up at 5 WAS. Crop data were taken on grain yield, 100-grain weight, husked and de-husked cob weights, number of grain rows per cob, plant height and number of leaves per plant. All the crop data collected were statistically analysed and the strength of relationship between yield components and tuber yield/ha was studied using correlation coefficient analysis (Little and Hills, 1978).

$$r = SP_{xy}/\sqrt{SS_x.SS_y}$$

Where r = Coefficient of correlation

SP_{xy} = Sum of product x and y $\sum$ (x-x) (y-y)

SS_x = Sum of squires of x $\sum (x-\bar{x})^2$

SS_y = Sum of squires of y $\sum (y-\tilde{y})^2$

The results of the above correlation were used to develop the following simultaneous equations in order to work out the path coefficients (P1-P5) (Dewey and Lu, 1959).

$r_{17} = P_1 + r_{12}P_2 + r_{13}P_3 + r_{14}P_4 + r_{15}P_5 + r_{16}P_6$ -----------------(1)

$r_{27} = r_{12}P_1 + P_2 + r_{23}P_3 + r_{24}P_4 + r_{25}P_5 + r_{26}P_6$------------------(2)

$r_{37} = r_{13}P_1 + r_{23}P_2 + P_3 + r_{34}P_4 + r_{35}P_5 + r_{36}P_6$------------------(3)

$r_{47} = r_{14}P_1 + r_{24}P_2 + r_{34}P_3 + P_4 + r_{45}P_5 + r_{46}P_6$------------------(4)

$r_{57} = r_{15}P_1 + r_{25}P_2 + r_{35}P_3 + r_{45}P_4 + P_5 + r_{56}P_6$-----------------(5)

$r_{67} = r_{16}P_1 + r_{26}P_2 + r_{36}P_3 + r_{46}P_4 + r_{56}P_5 + P_6$-----------------(6)

where P_1 - P_6 are path coefficients, while r_{12} –r_{67} are the coefficients of correlation. The direct and indirect effects of individual and combined (two factors) contributions of yield components to tuber yield/ha were determined using path-coefficient analysis. The combined contribution was estimated using the following formula:

$$C_{ij} = 2P_iP_j\, r_{ij}$$

where C = combined effect of i and j, r_{ij} = coefficient between i and j (i and j are the direct and indirect contributions) of yield components to tuber yield/ha were determined using path-coefficient analysis (Ajala *et al.,* 1996). The residual factor Rx that is unaccounted for by the direct and combined contributions was estimated using the following formula:

$$Rx = 1 - \sqrt{(P_1\, r_{17} + P_2\, r_{27} + P_3\, r_{37} + P_4\, r_{47} + P_5\, r_{57} + P_6\, r_{67})}$$

RESULTS AND DISCUSSION

Table 1 shows the type of relationships that exist between grain yield and some growth and yield characters of maize in 20052006 wet seasons and the combined. All the parameters measured significantly related to grain yield except numbers of grain rows per cob and leaves per plant in 2005 and number of grain rows in 2006 and the combined that were not significant. The correlation between grain yield and number of grain rows per cob in 2006 and number of leaves per plant for the combined were negative. In each of the year and the combined 100-grain weight had the strongest relationship with grain yield while number of grain rows recorded the weakest relationship with grain yield. The significant and positive correlation recorded between grain yield and 100-grain yield and husked and de-husked cob weights has indicates these parameters as important yield determinant in maize as early observed and reported by Jaliya *et al.* (2005) and Sharifai *et al.* (2006) on quality protein maize and early maize varieties, respectively. While the significant relationship recorded between grain yield and plant height and number of leaves have indicate the important of taller maize plants with disposed leaves that can intercepts more light necessary high assimilate production through photosynthesis thereby enhancing grain yield.

The relationships that exist among other growth and yield characters revealed the strongest relationship to be between husked and de-husked cob weight. The combined data had shown that number of leaves per plant negatively correlated with other growth and yield attributes except number of grain rows per cob (r = 0.1700) and plant height (r = 0.5112) with the latter being significant. The positive and stronger relationship recorded between husked and dehusked cob weight further indicates the degree of interdependence coexisting between these parameter. Larger husked cob invariably means larger de-husked cob because of the ability of the green husk to photosynthesise and contributed to the growth and development of the de-husked cob. The negative correlation recorded between number of leaves and number of grain rows and plant height might have aroused as a result of intra-plant competition for assimilates produced among these parameters and hence, given an indication of parasitism. This findings conforms with ones earlier reported by Jaliya *et al.* (2005) and Sharifai *et al.* (2006). Likewise the differential crop response to season and other edaphic and weather factors might be another contributing factor(s) to this effect.

When the total correlations were further partitioned into direct and indirect effect, it was observed that 100-grain weight in 2005 and the combined and husked cob weight in 2006 had the greatest effect on grain yield (Table 2). The greatest indirect effect on grain yield was from de-husked cob weight via 100-grain weight in 2005 (0.3296) and the combined (0.4434) and via husked cob weight in 2006 (0.5020). The weakest indirect effect on grain yield were from number of leaves via husked cob weight in 2005 (-0.0297), number of grain rows through de-husked cob weight in 2006 (0.0003) and 100-grain weight via number of grain rows per cob when the data for the two years were combined (-0.0067). The greatest direct effects and percent contributions of such parameters as 100-grain weight, husked cob weight to grain yield have shown that production of larger grains on bigger cobs is paramount to attending high yield in maize.

TABLE 1: Correlation matrix between yield and growth and yield components of maize at Samaru during 2005 and 2006 wet seasons and the combined

Characters	1	2	3	4	5	6	7
			2005				
1. Grain yield	1.000						
2. 100-grain weight	0.8095**	1.000					
3. Husked cob weight	0.6568**	0.6653**	1.000				
4. De-husked cob weight	0.6642**	0.6448**	0.8858**	1.000			
5. Grains' rows/cob	0.1741	0.2132	0.4474**	0.4926**	1.000		
6.Height/plant	0.7392**	0.5898**	0.6553**	0.6222**	0.4542**	1.000	
7.Leaves/plant	0.2049	0.3096*	0.3938*	0.3591*	0.4311**	0.3920*	1.0
			2006				
1. Grain yield	1.000						
2. 100-grain weight	0.8669**	1.000					
3. Husked cob weight	0.8862**	0.8105**	1.000				
4. De-husked cob weight	0.8387**	0.8074**	0.8899**	1.000			
5. Grains' rows/cob	-0.0087	-0.0154	0.0419	0.0171	1.000		
6.Height/plant	0.5151**	0.4754**	0.5562**	0.6010**	0.3184*	1.000	
7.Leaves/plant	0.3536*	0.3247*	0.5022**	0.4061**	0.1075	0.5630**	1.0
			Combined				
1. Grain yield	1.000						
2. 100-grain weight	0.9054**	1.000					
3. Husked cob weight	0.8679**	0.8595**	1.000				
4. De-husked cob weight	0.8532**	0.8396**	0.9416**	1.000			
5. Grain rows/cob	0.0274	0.0634	0.1345	0.1294	1.000		
6.Height/plant	0.2403*	0.1957	0.1474	0.0918	0.3646**	1.000	1.0
7.Leaves/plant	-0.3241**	-0.3100*	-0.3296**	-0.4350**	0.1700	0.5112**	

* = Significant (P=0.05), **= Significant (P=0.01)

TABLE 2:Direct and indirect effects of some growth and yield attributes of extra-early maize at Samaru during the 2005, 2006 wet seasons and the combined.

Characters	1	2	3	4	5	6	Total correlation
			2005				
1. 100-grain weight	0.495366	-0.0502	0.162835	-0.0397	0.276073	-0.03488	0.8095
2. Husked cob weight	0.329567	-0.07545	0.22362	-0.0833	0.306732	-0.04436	0.6568
3. De-husked cob weight	0.319412	-0.06681	0.252535	-0.09172	0.291239	-0.04046	0.6642
4. Rows/cob	0.105612	-0.03376	0.124399	-0.18619	0.212602	-0.04857	0.1741
5. Height/plant	0.292167	-0.04945	0.157128	-0.08457	0.468079	-0.04416	0.7392
6. Leaves/plant	0.153365	-0.02971	0.090685	-0.08027	0.183487	-0.11266	0.2049
			2006				
1. 100-GW	0.393835	0.457237	0.012975	0.000604	0.035254	-0.03301	0.8669
2. Huskd cob wt	0.319204	0.564142	0.0143	-0.00164	0.041246	-0.05105	0.8862
3. De-huskd cob weight	0.317983	0.50203	0.01607	-0.00067	0.044568	-0.04128	0.8387
4. Rows/cob	-0.00607	0.023638	0.000275	-0.03923	0.023612	-0.01093	-0.0087
5. Height/plant	0.187229	0.313776	0.009658	-0.01249	0.074157	-0.05723	0.5151
6. Leaves/plant	0.127878	0.283312	0.006526	-0.00422	0.04175	-0.10165	0.3536
			Combined				
1. 100-GW	0.515825	0.203421	0.130946	-0.0067	0.034145	0.027765	0.9054
2. Huskd cob wt	0.443351	0.236673	0.146854	-0.01422	0.025718	0.029521	0.8679
3. De-huskd cob weight	0.433087	0.222851	0.155962	-0.01368	0.016017	0.038961	0.8532
4. Rows/cob	0.032703	0.031833	0.020182	-0.10571	0.063614	-0.01523	0.0274
5. Height/plant	0.100947	0.034886	0.014317	-0.03854	0.174476	-0.04579	0.2403
6. Leaves/plant	-0.15991	-0.07801	-0.06784	-0.01797	0.089192	-0.08957	-0.3241

Figures in bold represents the direct effects.

TABLE 3: Percentage contributions of selected yield and growth attributes of extra-early maize to grain yield at Samaru during the 2005 and 2006 wet seasons and the combined.

	Percent contribution (%)		
Maize attribute	**2005**	**2006**	**Combined**
Individual characters			
1. 100-grain weight	24.53875	15.51064	26.60753
2. Husked cob weight	0.569336	31.82563	5.60142
3. De-husked cob weight	6.377415	0.025823	2.432425
4. Rows/cob	3.466565	0.153911	1.117359
5. Height/plant	21.90981	0.549924	3.044191
6. Leaves/plant	1.269197	1.033258	0.802198
Combined of two characters			
100-grain weight + husked cob weight	-4.97345	36.01524	20.98588
100-grain weight + de-husked cob weight	16.13257	1.021972	13.50904
100-grain weight + rows/cob	-3.93272	0.047588	-0.69138
100-grain weight + height/plant	27.35145	2.776868	3.522565
100-grain weight + leaves/plant	-3.45559	-2.59975	2.864407
Husked cob weight + de-husked cob weight	-3.37462	1.613485	6.951288
Husked cob weight + rows/cob	1.257071	-0.18547	-0.67297
Husked cob weight + height/plant	-4.62886	4.653725	1.217342
Husked cob weight + leaves/plant	0.669506	-5.7597	1.397356
De-husked cob weight + rows/cob	-4.6323	-0.00216	-0.42666
De-husked cob weight + height/plant	14.70963	0.143239	0.499607
De-husked cob weight + leaves/plant	-2.24075	-0.16407	0.920826
Rows/cob + height/plant	-7.91674	-0.18526	-0.134487
Rows/cob + leaves/plant	1.808515	0.085739	0.321896
Height/plant + leaves/plant	-4.13428	-0.84878	-0.59771
Residual	**19.22948**	**14.28814**	**12.93826**

The percent contribution of the parameters to grain yield of maize had shown revealed 100-grain weight as the highest contributor to grain yield in 2005 (25%) and the combined (27%) and husked cob weight in 2006 (32%) season. The second highest contributor to grain yield were plant height in 2005, 100-grain weight in 2006 (16%) and husked cob weight when the two years data were combined. Parameters that made the least contributions to grain yield of less than 1% were husked and dehusked cob weights and number of leaves per plant in 2005, 2006 and the combined, respectively. The highest combined contributions of two parameters to yield were from 100-grain weight + dehusked cob weight in 2005 (16%), and 100-grain weight + dehusked cob weight in 2006 (36%) and the combined (21%). While the least combined contributions of two plant characters of less than 1% to grain yield were from husked cob weight + number of leaves in 2005, 100-grain weight + grain rows per cob in 2006 and number of grain rows per cob + number of leaves per plant when the data for the two years were combined. The percent contributions that otherwise could not be explained were 19% in 2005, 14% in 2006 and 13% for the combined. Likewise the considerable contribution of plant height to grain yield could be as a result of the positive role this parameter play in exposing leaves for light interception thereby enhancing assimilate production through the process of photosynthesis. The negative contributions mostly recorded with number of grain rows in combination with most parameters might mean that seed size could be more important in attaining high yield in maize rather than the number of rows which the seeds occupy. The percent contributions that otherwise could not be explained were generally less than 20% for both seasons and the combined; with the combined having the least value of 13%. The result of this work revealed the importance of larger cobs and grains toward grain yield enhancement in extra-early maize variety.

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