ASSET Series A (2003) 3 (4):63-70

ISSN 1595-9694

GROWTH AND YIELD ANALYSIS OF IRRIGATED POPCORN *(Zea mays evarta)* GROWN IN KADAWA AS AFFECTED BY SOWING DATE AND INTRA-ROW SPACING, USING CORRELATION CO-EFFICIENT

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ABSTRACT

The experiment was designed to assess the effect of irrigation intervals (5, 7 and 9 days), sowing date at two week intervals (Mid and end of February and Mid March) and 3 intra-row spacing (20, 25 and 30 cm) on the performance of popcorn grown at Kadawa, Kano State, Nigeria (11°38'N,08° 02'E and 500m above sea level) using correlation co-efficient. Popcorn *(Zea mays evarta)* yield was found to be very strongly correlated with leaf area index (LAI) and total dry matter (TDM) of the crop. Yield analysis have shown that TDM and ear diameter have made the highest direct contribution, while the greatest combined contribution was made by plant height and TDM and cob and ear diameter. The total contributions (direct and indirect) were found to be 88.2, 50.8, 18.2 and 29.1 per cent in 1997 and 1998 dry seasons, respectively. Lower intra-row spacing of 20 cm, 7 - day irrigation interval and sowing at the end of February appeared to enhance popcorn grain yield significantly in both seasons.

Key words: Popcorn, Growth, Yield, Correlation Coefficient

INTRODUCTION

Popcorn is a cereal crop belonging to the large and important family Poeceae. It is one of the most widely used groups of maize all over the world including Nigeria. The crop has a shorter, more slender stalk and smaller ears and are earlier in maturity than the field corn. Because of the smaller size of the kernel planting is at thicker rate than for field corn (John *et al.,* 1967). The crop is used primarily for human consumption as freshly popped corn, snacks, confectioneries, biscuits, cornflakes and "tuwo" (Iken, 1993). In Nigeria Popcorn is made into "Gugguru" which is eaten alone or mixed in certain ratios with groundnut. The popcorn unfits for consumption are ground and used for fattening livestock. Improving the efficiency of popcorn production is therefore an important step towards agricultural and economic development in the country.

Corn, in general, is an efficient user of water. In drier areas moisture supply is one of the most important yield-limiting factor for the crop especially in non-irrigated areas (Lal, 1973). The best climate for the crop is that which receives an annual rainfall of between 600 and 1000mm, or its equivalent under irrigation. Optimum plant populat on per unit land area is an important cultural tool for the interception of adequate solar radiation needed for potential productivity, because it provides better plant canopy spread, efficient uptake of nutrients and water as well as easy performance of cultural operations (Onwueme and Sinha, 1991). Planting time is an important agronomic factor, which causes substantial increase or decrease in yield. Specifically, optimum planting time make the best use of the available temperature and solar radiation parameters at different stages of growth for high yield and its attributes (Rowland, 1993).

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Breeding this crop requires information on the nature and magnitude of variation in the available material, relationship of growth and yield components with yield and within growth and yield components and the degree of environmental influence on the expression of these growth and yield components. Since yield is a quantitative character that is a function of many related characters for an effective yield improvement, a simultaneous improvement of most growth and yield component characters is imperative (Ajala *et al.*, 1996).

This work seek to establish the relationship between yield of popcorn and some characters with the aim of identifying those traits that could be used to improve the final yield of the crop. It is expected that when this is achieved some important steps towards improving the efficiency of popcorn production could be evolved.

MATERIALS AND METHODS

The studies were conducted at the Institute for Agricultural Research Station, Kadawa, (11°38'N,08° 02'E and 500m above sea level) in the Sudan Savanna ecological zone of Nigeria, during 1997 and 1998 dry seasons. A split-plot design was used with the combinations of three irrigation intervals (5, 7, and 9-days) and three dates of sowing (Mid and end of February and Mid-March) randomized in the main-plot. The sub-plot treatments consisted of three intra-row spacings (20, 25 and 30 cm). The treatments were replicated three times. The soils of the experimental sites were sandy loam from 0 - 15 and'loam from 5 -30 cms in both seasons (Table 1).

Each sub-plot measured 6 x 3 m giving a gross plot of 18m^2. The net plot area was 6 x 1.5 m (9 m^2). Three seeds were planted and thinned to one plant per stand at 2

Table 1. Physical and chemical properties of the experimental site

	Soil depth			
	0 15 cm		15 - 30 cm	
	1997	1998	1997	1998
Physical characteristics (g/kg)				
Clay	17	33 18 30	35 28 35 32 35	54
Silt	25			
Sand	58			
Textural class	Sandy loam	Loan	Sandy loam	Loam
Chemical characteristics				
pH (1.2.5) in$_{H20}$	6.4	6.2	6.10	6.0
pH (1.2.5) in Cac12	5.7	5.4	5.80	5.50
Organic carbon (Mg/kg)	5.5	5.2	5.30	5.0
Total nitrogen (g/kg ')	1.0	0.8	1.10	1.00
Available phosphorus (ppm)	5.35	5.0	5.3	5.03
Exchangeable bases (coral./kg.)				
Ca	5.30	5.7	6.20	6.4
Mg	0.68	0.80	0.70	0.75
K	0.23	0.20	0.24	0.22
Na	0.24	0.21	0.23	0.22
Al	0.11	0.10	0.10	0.90
CEC	8.10	8.50		

WAS (Weeks after sowing). The irrigation treatment was started beginning from 4 WAS. Weeds were manually controlled using the hand hoe as and when necessary. Fertilizers were supplied as compound formulations (NPK: 15:15:15) at the rate of 120 kgN, 26 kgP and 50 kgK per hectare. It was applied in two split does, first half (60 kgN. 13 kgP and 25 kgK) at planting by drilling near the seeds and the remaining half was applied at 6 WAS using Urea (26

N). The crop was harvested at physiological maturity when the leaves and ears turned brown. The weather conditions during February to June, which was the period from planting to harvesting, are given in (Table 2).

The important growth and yield components that were correlated with yield and within yield parameters are plant height, LAI, TDM, ear diameter, cob diameter and weight of grain per cob.

Simple correlation coefficients between popcorn yield (Y) and these yield component (X) were worked out using the following formula:

$$r = \frac{Spxy}{\sqrt{SSx.SSy}}$$

Where

r = Coefficient of correlation.

SSxy = Sum of product of x and y [x-x] [y-y]

Table 2. Maximum and Minimum temperature and relative humidity at 10 - days intervals during the experimental periods at Kadawa in 1997 and 1998

		Temperatures (°C) Maximum		Minimum		Relative humidity (%) Maximum		Minimum	
Month		1997	1998	1997	1998	1997	1998	1997	1998
Feb.	1̄-10	33.3	38.7	42.2	15.3	15.0	16.0	8.0	7.0
	1 1 - 20	29.8	30.1	14.5	16.0	14.0	15.0	8.0	10.0
	2 - 28	30.0	31.0	15.0	16.6	14.0	15.0	8.0	10.0
March- i 1		30.5	30.6	16.5	17.1	14.0	15.0	9.0	10.0
	1)	34.0	35.1	17.5	19.4	15.0	14.0	7.0	8.0
	21- 1	35.2	36.0	18.5	19.5	13.0	14.0	7.0	8.0
April	1 1	35.2	40.1	19.0	21.4	15.0	17.0	9.0	7.0
	11- 20	36.5	41.9	20.5	23.3	16.0	49.0	8.0	7.
	1 - 30	35.4	37.3	18.5	25.4	13.0	82.0	7.0	29.0
May	1 0	35.5	37.2	22.5	24.9	18.0	.0	8.	32.0
	1 - 20	37.7	38.5	23.0	26.2	16.0	51.0	7.0	32.0
	21- 31	35.8	37.5	22.7	25.4	15.0	41.0	7.	38.0
June	I - i0	30.5	33.1	20.4	22.9	35.0	43.0	9.0	40.0
	1 1 - 20	31.2	34.2	19.5	22.2	37.0	70.0	1.0	43.0
	21 - 30	30.9	33.6	20.0	22.6	39.0	91.0	11.0	50.0

SSx = Sum of squares of x

SSy = Sum of squares of y

[y

Similarly, the coefficient of correlation between yield and its components and within the components, themselves were worked out suing the same formula. These correlations were further used to develop the following simultaneous equations in order to workout the path coefficients.

$$r_{12} \quad P_1 + r_{17}P_2 + r_{13}P_3 \quad \text{....(1)}$$
$$r_{24} \quad r_{17}P_1 + P_2 + r_{13}P_3 \quad \text{....(2)}$$
$$r_{34} \quad r_{13}P_1 + r_{12}P_2 + P_3 \quad \text{....(3)}$$

In the above equations, P_1, P_2 and P_3 are the path coefficients, while r_{17} .... r_{34} are the Coefficients of correlation. The path coefficients measure the direct contribution between yield and the concerned factors (growth and its components as well as yield components); whereas correlation coefficient measures a natural association between the two factors. Data collected were analysed statistically using F - test as described by Snedecor and Cochran, (1967). Correlation and path analysis were determined.

RESULTS

Simple correlation coefficient between growth, yield and its components are given in Table 3. The percentage contribution of individual growth parameters as well as combination of characters to yield (Table 4) revealed that moderate individual contributions were made by TDM and LAI which ranges from 13.8 - 15.6 and 1.57 - 24.6 percent. The lowest contribution of - 5.04 and 7.73 percent was made by plant height. The combination of plant height and LAI, plant height and TDM, LAI and plant height, LAI and TDM, TDM and plant height and TDM and LAI contributed 0.12 and 0.05, 1.82 and 1.10, -0.37 and - 1.90, 0.69 and 2.40, 0.24 and 0.06 and 1.02 and 0.55 percent to the grain yield, respectively. The remaining unaccounted residual was 88.2 and 50.2 percent, respectively.

When the percentage contribution of each yield character as well as combination of characters were examined (Table 5), the highest individual contribution of 11.9 and 18.5 percent was made by ear diameter; while the lowest contribution of -0.23 and 0.08 percent was made by cob diameter. Combination of ear diameter and cob diameter, ear diameter and weight of grain per cob, cob diameter and weight of grain per cob, weight of grain per cob and ear diameter and weight of grain per cob and cob diameter contributed -0.01 and 0.08, 0.18 and 0.47, 0.71 and 1.77, 0.69 and -

Table 3. Simple correlation coefficient between yield, yield components and within yield components

Growth and yield components	Seasons	
	1997	1998
Yield vs LAI	0.148	0.405**
Yield vs plant height	0.05	
Yield vs TDM	0.320**	0.493**
Yield vs ear diameter	0.376**	0.370**~
Yield vs cob diameter	0.086	i 0.038
Yield vs weight of grain/ cob		0.242*

* P < 0.05

** P < 0.01

Table 4 The percentage contributions of different growth characters to yield

Growth attributes	Percentage = Contributions	
	! 1997	1998
Individual contribution		
Plant height	-5.04	! 7.73
LAI	1. 7	24.6
TDM _	13.8	i 15.6
Combined contribution		
Plant height and LA 1	_	0.05
Plant height and TDM	1.82	1.10
LAI and plant height	-0.37	-1.90
LAI and TDM	0.69	2.40
TDM and plant height	0.24	0.06
TDM and LAI	1 1.02	0.55
Total	11.2	49.2
Residual	88.2	50.2^
	100.00	100.0

1.51, 0.009 and -0.011 and 0.36 and -0.76, 18.2 and 29.1 to the grain yield, respectively. The remaining unaccounted residual were 81.0 and 70.9, respectively.

The effect of intra-row spacing, irrigation interval and sowing date on popcorn grain yield (kg/ha) is presented in Table 6. Each increase in intra-row spacing from 20 - 30 cm resulted in a significant reduction in grain yield in 1998 season, however, the effect in 1997 season was not significant. Irrigation interval had no significant effect on popcorn grain yield in both seasons. Delayed sowing from mid - February to end of February significantly enhanced popcorn grain yield, a further delay in sowing to mid-March reduced grain yield significantly. Interaction between irrigation interval and sowing date on popcorn grain yield was significant (Table 7). At a given level of sowing dates increase in irrigation interval from 5 - 9 days was not significant except at the end of February sowing where increase in irrigation interval from 5 - 7 was not significant, a further increase to 9 - days significantly reduced grain yield (kg/ha). At a given levels of irrigation intervals, delayed sowing from mid-February to end of February significantly enhanced popcorn grain yield at 5 and 7 - days interval, a

Table 5. The percentage contribution of different yield character to yield

Growth attributes	Percentage	Contributions
	1997	1998
Individual contribution	11.9	18.5
! Ear dianiter	-0.23	0.08
Cob diameter	5.77	11.5
Weight of grain/cob		
Combined contribution	-0.01	0.08
Ear diameter and cob diameter	0.18	0.47
!t Ear diameter and weight of grain/cob	0.71	1.77
i Cob diameter and ear diameter	0.69	-1.51
Cob diameter and weight of grain/cob	0.009	-0.011
Weight of grain/cob and ear diameter	0.36	-0.76
I Weight of grain/cob and cob diameter	18.2	29.1
Total	81.80	70.9
Residual	100.00	100.00

Table 6. Effect of intra-row spacing, irrigation interval and sowing date on popcorn grain yield (kg/ha)

Treatment	1997	1998
	Inca-rows acin	
20 cm	1288	1414[a]
125cm	1255	1246
30 cm	1249	1031
SE (+)	55.8	31.3
Irrigation Intervals 0)		
5 - day	1231	11 24
- day	1360	
13 - day	12_01_	1164
SE (+)	115	59.3
Sowing date (D)		
Mid-February	1244'	1368
End_ of February	1425[a]	1532[a]
Mid-March	1124	79 L3`
SE (+) ~	115	59.3
Interaction		
I X D	NS	
I X P	NS	NS
D X P	NS	NS
! IXDXP		NS

Means followed by the same letter(s) within a treatment group are not significantly different at (P > 0.05) using DMRT.

further delay to mid-March, reduced grain yield significantly. At 9 - days interval, however, sowing date had no significant effect on popcorn grain yield.

DISCUSSION AND CONCLUSION

The correlation coefficient between yield and plant height was positive and highly significant in 1998 (Table 3). This is an indicative of the importance of this factor in carrying the plant in such away that interception of light is maximized. Similar observation was reported by Watson (1947).

Total dry matter per plant was also positive and highly significant in both seasons, such a consistent correlation in both trials is indicative of the fact that dry matter production is very important yield contributing factor in popcorn. Similar effect was reported by Ajala *et al.* (1996) that a very strong positive and highly significant correlation existed between total dry matter production and yield of sugar beet.

Leaf area index (LAI) was positive and highly significant only in 1998 ' season. This index is an estimate of photosynthetic activity of the crop. Thus, with a higher leaf area index, positive and highly significant correlation ($P < 0.01$) popcorn grain yield is therefore expected to be higher.

When the correlations with yield components were examined. It was indicated that ear diameter was positive and highly significant ($P < 0.01$) while grain weight/cob was positive and significant ($P<0.05$). this indicated the importance of yield components to popcorn grain yield. An increase in any of these parameters would contribute to increase in popcorn grain yield. This is in agreement to the findings of (Watson, 1958).

The path analysis and percentage contribution (Table 4) showed that most of the growth characters made their greatest contribution to yield through the TDM and LAI. This could oc due to the fact that increased dry matter and LAI are virtually synonymous with increased photosynthetic surface and thus greater photosynthate which is translated into higher yield. This is in agreement with what was reported by (Wright, 1960).

Table 7. Interaction between irrigation interval and dates of sowing on grain yield (kg/ha) in 1998

	owing date		
' Irrigation intervals (days) i	Mid-February	nd of February 1 ----'	Mid March 1
5	1151	1492 a	1083`
7	T 1308	1553	1062`
i 9	1294	1227`	ı100
SE (+)	59.3		

Means followed by the same letter(s) within a treatment group are not significantly different (P > 0.05) using DMRT.

Yield components made their greatest contribution through ear diameter and weight of grain per cob (Table 5). This showed that ear diameter and weight of grain per cob are the greatest yield determinant factors.

The higher yield at low intra-row spacing of 20 cm could be ascribed to more number of cobs per unit area which compensated for the reduction in yield of individual plants. Similar observation were reported by Roy and Singh (1986) and Onwueme and Sinha, (1991) who obtained highest popcorn grain yield at lower intra-row spacing of 15 and 20 cm, respectively. The non significant response of irrigation interval could be attributed to higher water table of Kadawa irrigation site, as well as closer irrigation intervals used which created an artificial water table which rendered the irrigation intervals non-significant. Similar finding were reported by Onwueme and Sinha (1991) and Rowland, (1993) that submergence of the soil for 3 - 5 days during seedlings or flowering period reduced the grain yield considerably.

Higher yield obtained with end of February sowing could be attributed to the favourable temperature, relative humidity and solar radiation during the period of flowering and fertilization (Table 6). This confirms the finding of Onwueme and Sinha (1991) that optimum sowing makes the best use of the available temperature and solar radiation during the period of flowering and fertilization. A higher grain yield recorded with 7 days interval and sowing at the end of February could be attributed to presence of favourable moisture condition for growth and development which resulted in better leaf development and overall plant growth provided by moderate irrigation interval as well as optimum temperature condition, solar radiation and relative humidity provided by the end of February sowing.

In conclusion, whereas other yield components contribute significantly to the yield of popcorn, the total dry matter production and ear diameter are the most important growth and yield contributing factors. Similarly, lower intra-row spacing of 20 cm, 7 - day irrigation interval and sowing at the end of February appeared to enhance popcorn grain yield (kg/ha).

REFERENCES

Ajala, B. A., Khan A. U. and Ahmed M. K. 1996. Yield Analysis of sugar beet *(Beta Vulgaris L.)*. Grown in Jos, Plateau State, Nigeria, Using correlation coefficients. *West $_{Afr.}$ J. Biol. Sci., Vol.* 5 No. 1.

Iken, J. E. 1993. Popcorn production and utilization, Maize Improvement, Production and Utilization in Nigeria IAR and T. Ibadan, Nigeria. pp 161 - 165

John, H. M. and W. H. Leonard 1967. Principles of Field Crop Production, The Macmillan Company Colliev-Macmillan Limited, London. 650 pp.

Lal R. 1973. The effect of seedbed preparation and time of planting of maize *(Zea inays L.)* in Western Nigeria. *Experimental Agriculture* 9:903 - 313.

Onwueme 1. C. and T. D. Sinha 1991. Field crop production in Tropical Africa. *Technical Centre for Agricultural and Rural Co-operation* (CTA) the Netherlands, 480 pp.

Rowland, J. R. J. 1993. Dryland farming in Africa. Technical Centre for Agricultural and Rural Co-operation (CTA) Macmillan Education Limited. 336pp.

Roy, R. K. and K. S. P. Singh 1986. Response of popcorn to plant population and nitrogen. *Indian Journal of Agronomy* 31(1):89 - 92 pp.

Snedecor, G. W. and W. G. Cochrarn 1967. Statistical methods 5''' ed. Iowa state University, pres U.S.A. pp. 456.

Watson, D. J. 1947. Comparative physiological studies on the Growth of Field Crops. 1. Variation in net assimilation rate and leaf area between species and varieties and within and between years. *Annals of Botany, London N. S. 11:* 41 - 47.

Watson, .D. J. 1958. The dependance of net assimilation rate on leaf area index. *Annals of Botany, London,* N.S:22 - 37 - 45.

Wright, S. 1960. Path coefficients and path regressions. Alternative or complementary concepts. *Biometrics* 16:198 - 202.