THE EFFECT OF SOWING DATES ANI) PLANT DENSITIES ON THE PERFORMANCE OF IRRIGATED POPCORN *(ZEA MAYS, EVERTA)*

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Abstract

Field trials were conducted during the 2000 and 2001 dry seasons, at the Kadawa Irrigation Research Station in the Sudan savannah of Nigeria, to study the effect of irrigation intervals, sowing dates and plant densities on the performance of popcorn (Zee/ *mays, everta)*. Treatments evaluated consist of factorial combination of three irrigation intervals (5, 7 and 9 days) and three sowing dates (Mid and end of February and mid-March) were assigned to the main plot, while three plant densities (44, 400; 53, 300 and 66. 600 plants/ha) were assigned to the sub-plot; with treatments replicated three times, in a split plot design. Increasing plant densities from 44, 400 to 66, 600 plants/ha, significantly enhanced the growth and yield parameters assessed, except days to 50% tasseling. Seven and nine days irrigation intervals, were statistically similar and significantly higher than 5-day irrigation interval, on all the growth and yield parameters. Late February sowing enhanced all growth and yield attributes significantly, than either mid-February or mid-March sowing.

Introduction

Popcorn *(Zen maws* everta), a member of the cereals family has recently become one of the important crops in Nigeria. The use of popcorn as confection and snacks has greatly increased demand for the crop, thus making it a profitable commercial crop. In the Zaria area of Kaduna State, popcorn production has been greatly promoted from subsistence level lor local consumption to large commercial scale for the food industry, particularly for snack food. Popcorn, like typical of maize variety, requires careful management of the environment and its resources in order to obtain a profitable yield (Iken. 1993). It is an alternative crop (in terms of production, harvest, storage and equipment requirements and practices) to those for Held corn or dent com. (Dhuyvetter, Henson and Nelson. 1991; Dcrozmason and Waldron, 1990; Ziegler. Ashman, White and Whyseng, 1985). The only difference betw een popcorn and dent corn, were found in the area of weed control and seed rate. These was attributed to the slow initial growth of popcorn and the kerned being very small (Iken, 1993).

Factors influencing crops productivity includes: crop variety, time of planting, soil type, soil organic matter and fertility, dates of sowing, cropping history, soil moisture, plant density and pests and diseases. Of these factors, three are of particular importance in determining the performance of popcorn namely: plant density, soil moisture and planting date (Hussaini, 2000). A very important factor in producing high yields and in obtaining best possible response of other factors, is a sufficient plant population. Until recently, most of the production systems in Nigeria have been restricted to the rainy season ecology. However, there has been a tremendous boost in irrigated cropping, particularly in the northern savannah areas. The production of maize under irrigation has in particular expanded steadily in response to increasing human population, food demand and favourable price (Hussaini, 2000). In order to enhance the economy of water use. reduce cost of production and maximize profit, various irrigation intervals were tried, with a view to determine the most appropriate interval for good growth and yield of the crop. The production of popcorn, which hither to was restricted to south of the country (Southern Guinea Savannah and Rain forest) has gradually shifted to the northern Guinea Savannah (in a similar trend with the field corn) which provides a better production environment with higher solar radiation, lower night temperatures, lower incidence of pests and diseases and ease of drying. However this potential can only be realized with appropriate planting time. In view of this, a study was undertaken to determine the effects of plant density, irrigation interval and sowing date on the growth and yield of irrigated popcorn.

Materials and Methods

A two-year field study was conducted during 2000 and 2001 dry seasons at the Irrigation Research Station of the Institute for Agricultural Research (IAR) Kadawa (11° 39’N, 08° 02' E and 500m above sea level) in the Sudan savannah ecology to study the effect of plant density, irrigation interval and date of sowing. Factorial combination of irrigation interval (5, 7 and 9 days) and sowing dates (Mid and End of February and Mid-March) were randomised in the main-plot and plant density (66, 600; 53, 300 and 44, 400 plants/ha) was assigned to the sub-plot in a split-plot design and replicated three times. The study was conducted on a well drained and moderately acid soil (PFI in H_20 of 6.4), sandy loam soil, classified as a fine sandy loam with an organic matter content of 5.5g kg' ^{1} and total N of 1.10g kg^{-1}, respectively.

A gross plot size of four rows (75cm apart) and 6m long ($18m^2$) was used for the trials and the net plot area consisted of two centre rows of 6m length ($9m^2$). Two seeds were sown per hill in rows 75cm apart at the planting distance of 20cm along the row's. At two weeks after planting (WAP) the crop was thinned to one plant per stand. Irrigation treatment was imposed beginning from 4WAP. Weeds were controlled manually using manual hoc at 3, 6 and 9 WAP. Fertilizers were supplied at the rate of 120kgN, 26 kg P and 50 Kg k per hectare, using compound fertilizer (NPK:20:10:10). The weather conditions during January to June which was the period of planting to harvesting are given in Table 1.

The crop was harvested when the husks had dried to brown colour indicative of full maturity. Data were collected on plant height, which was measured using metre ruler from the ground level to the tip of the upper most leaf. Number of days to 50% tasseling was the number of days from planting to when 50% of the plant tasseled. Leaf area index (LAI) at tasseling, where the length and maximum breadth of a functional leaf were taken and multiplied by a factor 0.75 (crop factor for maize). Popping percentage was determined by sampling of 100 seeds in each plot and popping was performed using 20 mls vegetable oil per 100 seed sample for a period of 3 minutes. Number of popped seeds were counted and expressed as popping percentage. 1000 grain weight was determined by counting 1000 seeds from each plot randomly and weighed. Grain yield (Kg/ha) was computed by weighing the cleanned grains from the net plot area. The data collected were subjected to statistical analysis of variance and where "F" test showed significant difference, the means of such treatments were then compared using Duncan Multiple Range Test (DMRT.) (Duncan 1955).

Result

The response of plant height and LAI as influenced by plant density, irrigation interval and sowing date are presented in Table 2. Plant density significantly influenced plant height and LAI in all the seasons and combined mean. Each increase in plant density was accompanied with a significant increase in plant height and LAI except plant height in 2000 which was not significant. Increase in irrigation interval from 5 to 7-day significantly enhanced plant height in 2001 and LAI in all the seasons, further increase in irrigation interval beyond 7-day was statistically similar. Delayed sowing from mid-February to end of February significantly increased plant height and LAI, further delay to mid-March significantly reduced these parameters.

The influence of plant density, irrigation interval and sowing date on days to 50% tasseling and popping percentage are presented in fable 3. Plant density significantly influenced days to 50% tasseling and popping percentage in 2001 and combined mean. Increasing plant density from 44,400 to 66,600 plants/ha significantly increased days to 50% tasseling and popping percentage. Increasing irrigation interval from 5 to 7 days significantly look longer days to 50% tasseling in 2001 season which was statistically similar with that at 9-day interval. Similarly, increasing irrigation interval from 5 to 7 days enhanced popping percentage in 2001, in combined mean, however, the differences was not significant. A further increase in irrigation interval beyond 7-day significantly depressed popping %. Delayed sowing from mid-February to mid-March significantly depressed days to 50% tasseling. The differences between mid-February and end of February sowings were statistically similar and produced significantly higher popping percentage than mid-March sowing.

Table 4 shows the effects of plant density, irrigation interval and sowing date on 1000-grain weight and grain yield (kg/ha). Each increase in plant density from 44,400 to 66,600 plants/ha, significantly depressed 1000-grain weight but increased grain yield/ha in 2001 and combined mean. Varying irrigation interval had no significant effect on 1000-grain weight and grain yield kg/ha in all

the years and combined mean. Delayed sowing from mid-February to end of February significantly enhanced 1000-grain weight and grain yield (kg/ha), a further delay to Mid-March depressed these parameters.

Irrigation interval x sowing dates interaction on LAI and grain yield (kg/ha) were significant. (table 5). Varying irrigation interval had no significant effect on LAI at mid-February and mid- March sowing but significantly increased LAI at End of February sowing from 5 to 7 days. Further increase in irrigation interval to 9-day significantly depressed LAI. Delayed sowing from mid to End of February did not significantly affected LAI at 5 and 9 days irrigation interval but significantly increased LAI at 7-day interval. Further delay to mid-March significantly enhanced LAI at 5 and 9 days interval. Varying irrigation interval had no significant effect on grain yield (kg/ha). Delayed sowing from Mid to End of February at 5 days interval enhanced grain yield/ha (kg/ha) but the yield were statistically similar at 7 and 9 days and significantly higher than grain yield obtained at Mid- March sowing.

Discussion

Increasing plant density from 44,400 to 66,600 plants/ha significantly enhanced plant height and LAI. these could be probably ascribed to competition among plants for the available light, water and nutrients as well as increased shading effect, thereby, making the plants to grow taller so as to intercept more solar radiation for the production of assimilates. These support the findings of Olson and Sander (1988) who reported that plant height and LAI increased significantly with increase in plant density, through an increase in internode length and more number of leaves per plant. The delay in days to 50% tasseling with increasing plant density could be attributed to the fact that since the plant were not widely spaced, there was a tendency of space, light and moisture to be limited which encourages prolong vegetative growth period. Similar observation was reported by Pierre, Aldrich and Martiu (1967) that tasseling and silking was delayed by 1 to 5 days with increase in plant density. The decrease in 1000-grain weight and popping % with increase in plant density could also be ascribed to interplant competition for the growth factors, thereby affecting translocation of assimilates to the ear. This supported the findings of Filho, far, Malheines and Aguilar (1988), who reported a decrease in popping %, 1000 grain weight and weight of grain per ear with increase in plant density. The increase in grain yield with increased plant density could be due to more number of cobs per unit area, which had compensated for the reduction in yield of the individual plants. Similar effect were reported by Brunson and Smith (1948), Roy and Singh (1986) and Onweme and Sinha (1991).

The response of popcorn to irrigation interval on plant height and LAI were significant with 7-day interval and had an edge over other intervals. This could be attributed to the moderate irrigation application which provided a more favourable moisture condition for good crop growth and development, better leaf development and dry matter accumulation. Besides the shallow rooting which the moderate irrigation interval of 7 days might have induced, the plants probably had access to the adequate moisture supply provided throughout the growth and reproductive period. Michael (1978), and Anon (1983) reported that higher grain yield and its attributes were obtained at 7 days irrigation interval than 3. 5 or 10 days.

Sowing date significantly affected plant height, LAI, days to 50% tasseling in 2001 and combined, popping percentage in 2000 and combined, 1000 grain weight in 2001 and grain yield. Delayed sowing from Mid-February to end of February significantly enhanced the above parameters except days to 50% tasseling which was significantly depressed with delay in sowing. Further delay to Mid - March however, depressed these parameters significantly. The low yield of the early sow-n popcorn in Mid-February could be attributed to low temperature and excessive cloud cover, as well as high Relative Humidity (R.H.) at the initial growth stage of the crop, thereby affecting its performance. Similarly the low yield of the late sown popcorn in Mid-March could be ascribed to higher temperature, low relative humidity during vegetative and reproductive stages of the crop.

The higher grain yield obtained at the end of February sowing could be explained as the result of favourable temperature, relative humidity and solar radiation which were in abundant during the period of flowering and fertilization. Kumar, Owonubi and Aremu (1982) Anon (1983) and Onwueme and Sinha (1991) reported similar observations, that optimum sowing makes the best use of the available temperature and solar radiation during the period of flowering and fertilization. The environment with cool night temperature (14 - I8°C) becomes more favourable to maize production.

Increase in minimum temperature by 1"C (night-temperature) beyond 14°C resulted in decreased grain yield by 153 Kg/ha (Kumar *et al*, 1982). However, 1°C increase in mean temperature beyond 30°C (Max. temperatures 38°C) caused the decrease in grain yield of maize by more than 21 1 Kg/ha. This indicated that maize fertilization and grain growth is a function of optimum temperature during the day and night, respectively.

Interaction between irrigation interval and sowing dates on LAI and grain yield (combined) were significant, (Table 5). Increased irrigation interval from 5 to 7 days significantly enhanced LAI at the end of February sowing and grain yield (Kg/ha) at Mid-February sowing. Further increase in irrigation intervals to 20-day at these dates of sowing significantly depressed these parameters. These could be ascribed to the favourable temperature, relative humidity and solar radiation during the period of flowering and fertilization as well as moderate irrigation interval of 7-day, which provided more favourable moisture condition for good growth, development, accumulation of dry matter, yield and overall plant growth.

Conclusion

Based on the findings of this study, it could be suggested that sowing popcorn at highest plant density of 66,600 plants/ha, at 7-day irrigation interval and using the sowing date of late February seemed to promote good crop growth and optimum grain yield of irrigated popcorn in the Sudan Savannah ecology of Nigeria.

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Table 1: Physico Chemical Properties of the Soil Up to 30 cm Depth of the Experimental Site at Kadawa

Soil Physical Characteristics	2000	2001
Sand (%)	58	54
Silt (%)	25	28
Clay (%)	17	18
Textural class	Sandy loam	Sandy loam
Chemical composition		
pH in ITO (1:2.5)	6.4	6.10
pH in 0.1 CaCE (1:2.5)	5.7	5.80
Organic Carbon (g/kg'^{1})	5.5	5.30
Total nitrogen (g/kg"^{1})	1.0	1.10
Available phosphorus (mg/kg^{-1})	5.35	5.32
Exchangeable bases (Mol$_c$ kg^{-i})		
Ca	5.30	6.20
Mg	0.68	0.70
K	0.23	0.24
Na	0.24	0.23
CEC	0.1 1	0.10

Soil samples as analyzed at the Soil Science Department IAR/ABU Zaria.

Table 2: Effect of Sowing Date, Plant Density and Irrigation Interval on Plant Height (12 WAP) and LAI at Tasseling

Treatment	Plant height			LAI		
	2000	2001	Combined	2000	2001	Combined
	------------------ cm --------- ----- —					
Plant density (P)						
66,600	150.7	130.7^{ai}	140.7^{a}	3.49^{a}	3.37^{a}	3.42^{a}
53,300	150.5	125.8^{b}	138.2^{a}	3.37^{b}	3.30^{b}	3.37^{b}
44,400	147.4	120.8^{C}	134. l^{b}	3.32°	3.22^{c}	3.29^{e}
SE (+)	1.70	0.47	1.09	0.02	0.02	0.013
Irrigation interval (I)						
5	150.3	123.9^{b}	137.1	3.37^{b}	3.26^{b}	3.29^{b}
7	147.6	124.6^{ab}	136.1	3.44^{a}	3.29^{ab}	3.32^{a}
9	150.8	129. *T*	140.3	3.39^{a}	3.29^{ab}	3.32^{a}
SE(+)	3.28	1.50	2.39	0.02	0.02	0.02
Sowing date (D)						
Mid-Feb.	134.6^{b}	124.7$^{1’}$	129.7^{b}	3.39^{ab}	3.28^{b}	3.32$^{1’}$
End of Feb.	156.2^{a}	125.0$^{1’}$.	140.6^{a}	3.44^{a}	3.56^{a}	3.38^{a}
Mid-March	158.0"	130.6^{3}	144.3"	3.37^{b}	3.25^{b}	3.33^{b}
SE (+)	3.28	1.50	2.39	0.02	0.02	0.02
Interactions						
1 x D	NS	NS	NS	**	NS	NS

'Mean followed by the same letter(s) within a treatment group arc not significantly different at percent level of probability using DMRT.

** = Significant at P = 0.01
NS = Not significant

Table 3: Effect of Sowing Dates Plant Density and Irrigation Interval Days to 50% Tesseling and Popping Percentage

Treatments	Tasseling			Popping		
	2000	2001	Combined	2000	2001	Combined
	%			%		
Plant density (P)						
66,600	66.6	62.2^{c}	64.6^{c}	76.9	76.7^{a}	79.3^{a}
53,300	66.8	64.9^{b}	65.9^{b}	75.9	69.0^{b}	72.8^{b}
44,400	67.2	67.1^{a}	66.9^{a}	75.0	51.2^{c}	60.4^{c}
SE (±)	0.38	0.13	0.28	1.57	1.55	1.32
Irrigation interval (I)						
5	67.0	63.7^{b}	65.2	76.3	63.3^{b}	70.2^{a}
7	66.7	65.3^{a}	66.2	77.4	73.1^{a}	74.6^{a}
9	67.0	65.2^{a}	65.9	74.0	60.5^{b}	67.8^{b}
SE (±)	0.56	0.33	0.46	1.71	2.34	2.12
Sowing date (D)						
Mid-Feb.	69.5	66.8^{a}	68.1^{a}	97.4^{a}	64.2	71.0^{a}
End of Feb.	64.2	62.9^{c}	65.8^{b}	78.8^{a}	69.7	73.6^{a}
Mid-March	67.0	64.5^{b}	63.5^{c}	71.5^{b}	63.0	67.9^{b}
SE (±)	0.56	0.33	0.46	1.71	2.34	2.12

'Means followed by the same letter(s) within a treatment group are not significantly different at 5 percent level of probability using DMRT.

Table 4: Effect of Plant Density, Irrigation Interval and Dates of Sowing on 1000-Grain Weight and Grain Yield (kg/ha)

Treatments	1000 Grain Weight			Grain Yield		
	2000	2001	Combined	2000	2001	Combined
	(gm)			(kg/ha)		
Plant density (P)						
66,600	138.0	141.0[c1]	137.2[c]	1288	1414[a]	1187[a]
53,300	139.0	150.0[b]	147.0[b]	1255	1246[b]	1219[b]
44,400	140.0	159.1[a]	156.0[a]	1249	1031[c]	1116[b]
SE (±)	2.27	1.28	1.18	55.80	31.30	44.20
Irrigation interval (I)						
5	140.0	151.0	146.2	1231	1194	1228
7	140.2	151.0	147.0	1360	1334	1311
9	136.2	150.0	146.4	1201	1164	1182
SE (±)	3.38	1.28	1.42	115.00	59.30	94.10
Rates of sowing (D)						
Mid-Feb.	136.3	147.1[b]	146.0[b]	1244[b]	1368[a]	1309[a]
End of Feb.	144.4	155.0[a]	151.0[a]	1425[a]	1552[a]	1479[a]
Mid-March	135.3	146.3[b]	143.0[b]	1124[b]	791[b]	934[b]
SE (±)	3.38	1.28	1.42	115	59.30	94.10
Interactions						
I x D	NS	NS	NS	**	NS	NS

'Means followed by the same letter(s) within a treatment group are not significantly different at 5 percent level of probability using DMRT.

** = Significant at P = 0.01 NS = Not significant

Table 5: Interactions Between Irrigation Interval and Dates of Sowing on LAI at Tasseling in 2000 and Grain Yield (kg/ha) Combined Analysis.

Treatments	LAI			Grain Yield (kg/ha)		
	Sowing Date					
	Mid-Feb.	End of Feb.	Mid-March	Mid-Feb.	End of Feb.	Mid-March
Irrigation intervals (I)						
5	3.26[c]	3.30[e]	3.40[cd]	1150.5[c]	1492.8[ab]	1082.7[c]
7	3.34[de]	3.60[a]	3.53[abc]	1308.0[abc]	1553.0[a]	1062.3[c]
9	3.30[e]	3.30[e]	3.49[bc]	1293.6[abc]	1227.5[b]	1085.1[c]
SE (±)	0.03			94.1		

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significant using DMRT.

Appendix I. Maximum and Minimum Temperature and Relation Humidity at 10–D Intervals During the Experimental Periods at Kadawa in 1999/2000 and 2000/2001

		Temperatures (^{0}C)				Relative humidity (%)			
		Maximum		Minimum		Maximum		Minimum	
Month	Days	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01
Feb.	1 – 10	33.3	38.7	42.2	15.3	15.0	16.0	8.0	7.0
	11 – 20	29.8	30.1	14.5	16.0	14.0	15.0	8.0	10.0
	21 – 28	30.0	31.0	15.0	16.6	14.0	15.0	8.0	10.0
March	1 – 10	30.5	30.6	16.5	17.1	14.0	15.0	9.0	10.0
	11 – 20	34.0	35.1	17.5	19.4	15.0	14.0	7.0	8.0
	21 – 31	35.2	36.0	18.5	19.5	13.0	14.0	7.0	8.0
April	1 – 10	25.2	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	7.0
	21 – 30	35.4	37.3	18.5	25.4	13.0	82.0	7.0	29.0
May	1 – 10	35.5	37.2	22.5	24.9	18.0	87.0	8.0	32.0
	11 – 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	7.0	38.0
June	1 – 10	30.5	33.1	20.4	22.9	35.0	43.0	9.0	40.0
	11 – 20	31.2	34.2	19.5	22.2	37.0	70.0	10.0	43.0
	21 – 30	30.9	33.6	20.0	22.6	39.0	91.0	11.0	50.0

Source from met. Station of IAR Kadawa 2001.