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Growth and Yield of Popcorn (*Zea mays* everta sturt) as Influenced by Irrigation Scheduling and Nitrogen Levels

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A field experiment was conducted during *rabi* 2011 on popcorn consisting four levels of irrigation (Irrigation at critical growth stages, 0.6, 0.8 and 1.0 IW:CPE ratios) and four levels of nitrogen (80, 100, 120 and 140 kg N ha^{-1}). Growth and yield attributes of popcorn were significantly improved due to irrigation scheduling at 0.8 and 1.0 IW:CPE ratios over lower levels of irrigation. Significantly higher popcorn grain (8.47, 22.00 and 25.09 per cent) and stover (5.31, 19.47 and 26.68 per cent) yields were obtained under 1.0 IW:CPE ratio as compare to 0.8, 0.6 IW:CPE ratios and irrigation at critical growth stages, respectively. The increasing levels of nitrogen significantly improved growth, yield and yields attributes up to 140 kg N ha^{-1}. However, it was remained at par with 120 kg N ha^{-1}. The highest net return of ' 74779 ha^{-1} (BCR = 2.98) were obtained at 1.0 IW:CPE ratio with 120 kg N ha^{-1}. So it is advisable that, for securing higher profit and yield the popcorn should be irrigated at 1.0 IW:CPE ratio with application of 120 kg N ha^{-1}.

Key word: IW:CPE ratio, Popcorn, BCR.

Among the different types of maize, popcorn (*Zea mays* everta sturt) is popular as a snack food in many parts of world. It's kernals are composed of hard starch, when heated, swell and brust. Because of low sugar, fat and calories it is good food for health. Popcorn has shorter, more slender stalk and thinner cobs than field maize. It contains dietary fiber 15 g, thiamine 0.2 mg, riboflavin 0.3 mg, 12 g protein, 4 g fat and 2.7 mg iron per 100 g of edible portion. It has tremendous potentially because it gives more remuneration to the farmer. Because of its uniqueness for diverse uses as well as responsiveness to inputs, maize has tremendous potential in ensuring sustainability and food security in India. Among the various agronomic inputs, irrigation and nitrogen are important ones for achieving the higher productivity of popcorn.

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MATERIALS AND METHODS

The experiment was laid out during *rabi* season of 2011 at college agronomy farm, B. A. College of Agriculture, AAU, Anand in a split plot design with four levels of irrigation (Irrigation at critical growth stages, 0.6, 0.8 and 1.0 IW:CPE ratios) relegated to main plots and four levels of nitrogen fertilizer (80, 100, 120 and 140 kg N ha^{-1}) were assigned to sub plots. In all 16 treatment combinations were replicated four times. The popcorn variety 'Amber' was used in the experiment as a test crop. The soil of the experimental plot was loamy sand in texture with 7.7 pH and 0.22 dSm^{-1} EC. Soil was low in available N (227.60 kg ha^{-1}), medium in available P_2O_5 (45.30

kg ha^{-1}) and high in available K_2O (281.12 kg ha^{-1}). Irrigation at critical growth stages were applied at leaf stage, early knee-height stage, tasseling stage, 50% silking and dough stage. Nitrogen was applied into three splits *viz*, 50% as basal, half of remaining dose in two equal splits, at knee high and silking stages. The plant height and yield attributes were observed from five plants sampled randomly from each plot. The grain and stover weight plot^{-1} were recorded and converted into kg ha^{-1}. The gross realization in terms of rupees per hectare was worked out taking into consideration the yields of each treatment and prevailing market price. The net profit was worked out by deducting the total cost of cultivation from gross realization for each treatment and recorded accordingly. The benefit : cost ratio (BCR) for each treatment was calculated by Net realization (` ha$^{-1}$) divided by total cost of cultivation (` ha^{-1}).

RESULTS AND DISCUSSION

Growth and Yield Attributes

The results indicate that, most of the growth and yield attributes *i.e.* plant height, number of cobs plant^{-1}, cob length, cob girth, number of rows cob^{-1} and number of grains cob^{-1} of popcorn were significantly influenced due to different levels of irrigation scheduling. Significantly higher values of these parameters were recorded under irrigation scheduling at 1.0 IW:CPE ratio as compared to irrigation at critical growth stages and 0.6 IW:CPE ratio. However, it was at par with 0.8 IW:CPE ratio. This might be due to more total quantity of water applied under 1.0 and 0.8 IW:CPE ratios as a result, soil moisture maintained in readily available range during active plant growth stage. Same results are also found by Tyagi *et al.*, (1998). Application of nitrogen @ 140 kg ha^{-1} recorded significantly higher growth and yield attributes as compared to 100 and 80 kg N ha^{-1} but it was remained at par with 120 kg N ha^{-1}. This might be due to easy and greater availability of nitrogen at higher rates of nitrogen. Kumar (2008) also reported similar results.

Table 1. Influence of irrigation scheduling and nitrogen levels on growth and yield attributes of popcorn

Treatment	Plant height (cm)	Number of cobs plant^{-1}	Cob length (cm)	Cob girth (cm)	Number of rows cob^{-1}	Number of grains cob^{-1}	Shelling (%)
Irrigation (I)							
I_0	159.41	1.46	13.41	8.81	13.35	292.67	70.83
$I_{0.6}$	164.47	1.49	13.80	8.97	13.44	298.94	72.66
$I_{0.8}$	173.34	1.64	15.64	9.62	14.10	322.40	77.10
$I_{1.0}$	179.93	1.68	16.78	10.02	14.92	335.76	78.50
S. Em. +	4.35	0.05	0.47	0.25	0.37	9.66	1.80
CD (P=0.05)	13.91	0.15	1.49	0.80	1.18	30.89	5.77
Nitrogen (N)							
N_{80}	155.59	1.41	13.44	8.49	12.73	279.80	70.07
N_{100}	166.92	1.54	14.61	9.16	13.66	306.82	73.70
N_{120}	174.31	1.63	15.69	9.73	14.45	324.59	76.75
N_{140}	180.32	1.70	15.89	10.05	14.97	338.56	78.58
S. Em. +	3.22	0.04	0.30	0.21	0.32	6.99	1.60
CD (P=0.05)	9.24	0.11	0.87	0.61	0.91	20.05	4.60
Interaction (I x N)	NS	NS	Sig.	NS	NS	NS	NS

*I_0 : irrigation at critical growth stages

Table 2. Interaction effect between irrigation scheduling and nitrogen levels on popcorn

Treatment	Cob length (cm)			
	N_{80}	N_{100}	N_{120}	N_{140}
I_0	12.82	13.30	13.56	13.96
$I_{0.6}$	13.05	13.93	14.15	14.09
$I_{0.8}$	13.49	15.47	16.25	17.36
$I_{1.0}$	14.40	15.75	18.80	18.16
S. Em. ±		0.59		
CD (P=0.05)		1.69		
C.V %		7.92		

Interaction effect between irrigation scheduling and nitrogen levels for the cob length was found significant (Table 2). Treatment combinations irrigation scheduling at 1.0 IW:CPE ratio with application of 120 kg N ha^{-1} recorded significantly higher cob length (18.80 cm) as compare to rest of the treatment combinations except irrigation scheduling at 0.8 IW:CPE ratio with application of 140 kg N ha^{-1} and irrigation scheduling at 1.0 IW:CPE ratio with application of 140 kg N ha^{-1}. Similar result was also reported by Jat *et al*., (2008).

Table 3. Influence of irrigation scheduling and nitrogen levels on yield and economics of popcorn

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Net realization (‘ ha^{-1})	BCR
Irrigation (I)				
I_0	2682	4397	48759	2.14
$I_{0.6}$	2750	4662	50724	2.23
$I_{0.8}$	3093	5289	59556	2.58
$I_{1.0}$	3355	5570	66017	2.81
S. Em. +	90.22	138.59		
C. D. (P=0.05)	288.62	443.37		
Nitrogen (N)				
N_{80}	2688	4295	49593	2.26
N_{100}	2922	4833	55686	2.51
N_{120}	3110	5263	60618	2.70
N_{140}	3161	5527	61779	2.71
S. Em. +	59.31	100.85		
C. D. (P=0.05)	170	289		
Interaction (I x N)	Sig.	NS		

Table 4. Interaction effect between irrigation scheduling and nitrogen levels on popcorn

Treatment	Grain yield (kg ha^{-1})			
	N_{80}	N_{100}	N_{120}	N_{140}
I_0	2565	2660	2712	2793
$I_{0.6}$	2609	2786	2830	2775
$I_{0.8}$	2698	3093	3138	3444
$I_{1.0}$	2880	3150	3761	3632
S. Em. ±		188.63		
CD (P=0.05)		340		
C.V %		7.99		

Yield

Popcorn grain and stover yields were significantly higher under irrigation scheduling at 0.8 and 1.0 IW: CPE ratios as compared to irrigation at critical growth stages and 0.6 IW:CPE ratio. Treatments 1.0, 0.8 and 0.6 IW:CPE ratios recorded 25.09, 15.32 and 2.53 per cent higher popcorn grain yield and 26.68, 20.29 and 6.02 per cent higher stover yield than irrigation at critical growth stages, respectively. The increase in popcorn yield might be due to the effect of timely and frequent irrigation provide constant wet root zone, enhanced growth

Table 5. Economics of different treatment combinations

Treatment	Net Realization (‘ ha^{-1})				BCR			
	N_{80}	N_{100}	N_{120}	N_{140}	N_{80}	N_{100}	N_{120}	N_{140}
I_0	44077	46677	48252	50050	1.86	1.94	1.98	2.03
$I_{0.6}$	45337	50194	51361	50000	1.91	2.09	2.11	2.03
$I_{0.8}$	48061	58051	59210	66922	1.99	2.38	2.40	2.68
$I_{1.0}$	52388	59937	74779	71609	2.14	2.42	2.98	2.82

and yield attributes and ultimately higher popcorn yield. Rajendran and Singh (1999) also reported the similar findings. Grain and stover yields of popcorn were gradually increased with increase in levels of nitrogen up to 140 kg ha^{-1}. However it was comparable with 120 kg N ha^{-1} (Table 3). Per cent increase in grain and stover yields under 100, 120 and 140 kg N ha^{-1} over 80 kg N ha^{-1} was at the tune of (8.70, 12.52), (15.70, 22.53) and (17.60, 28.68) per cent, respectively. The cumulative beneficial effect of growth and yield attributes was finally reflected in grain and stover yields of popcorn. These findings are in agreement with Thakur *et al.*, (1998) and Kumar (2009).

Interaction effect between irrigation scheduling and nitrogen levels for the grain yield was found significant (Table 4). Treatment combinations irrigation scheduling at 1.0 IW:CPE ratio with application of 120 kg N ha^{-1} recorded significantly higher grain yield (3761 $kgha^{-1}$) as compare to rest of the treatment combinations except irrigation scheduling at 0.8 IW:CPE ratio with application of 140 kg N ha^{-1} and irrigation scheduling at 1.0 IW:CPE ratio with application of 140 kg N ha^{-1}.

Economics

The highest net realization of ‘ 66017 ha^{-1} with BCR value of 2.81 were secured under irrigation scheduling at 1.0 IW:CPE ratio as compare to rest of the irrigation treatments. An application of 140 kg N ha^{-1} registered the highest net realization of ‘ 61779 ha^{-1} with BCR of 2.71 closely followed by application of 120 kg N ha^{-1} (2.70). However, the highest net return in treatment combination of ‘ 74779 ha^{-1} with BCR value of 2.98 were obtained at 1.0 IW:CPE ratio with 120 kg N ha^{-1}. It is due to increase in yield and simultaneously saving 20 kg nitrogen per hector which reduce input cost of fertilizers.

CONCLUSION

From the result of experiment, it is concluded that, for securing higher yield and profit from popcorn during *rabi* season under middle Gujarat conditions, total 7 irrigations of 50 mm depth should be applied at 1.00 IW:CPE ratio. First irrigation should be applied immediately after dry sowing, second irrigation at 16 DAS, remaining five irrigations at 13 to 17 days interval should be applied along with nitrogen @ 120 kg N ha^{-1}.

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