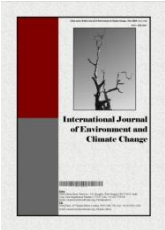

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Performance Evaluation of Sweetcorn with Different Levels of Irrigation and Nitrogen through Drip during Post Monsoon Season at Rajendranagar, Hyderabad, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author YSL designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author DS managed the literature searches. Author TP managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The present study on Performance evaluation of Sweetcorn with different levels of Irrigation and nitrogen through drip during post monsoon season at Rajendranagar, Hyderabad, India was conducted for two years at Maize Research Centre, Agricultural Research Institute (ARI), Rajendranagar, Hyderabad to assess the influence of different levels of irrigation and nitrogen on performance of sweetcorn hybrid. Randomized block design with factorial concept was used in the study and the experiment was replicated thrice. The treatments used were two factors. Factor I was five irrigation levels viz., I_1: Drip irrigation at 60% E pan, I_2: Drip irrigation at 80% E pan, I_3: Drip

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irrigation at 100% E pan, I_4:Drip irrigation at 120% E pan andI_5: Surface irrigation at IW/CPE- 1.0 and Factor II was four nitrogen levels in kg ha^{-1} viz., N_1: 120, N_2: 160 N_3: 200 N_4: 240. Pooled mean of two years revealed that, drip irrigation with 120% E pan which was on par with 100% E pan showed significantly better crop performance in terms of growth characteristics like plant height, Leaf Area Index and dry matter production and both were superior to drip irrigation of 80 and 60% E pan as well as surface irrigation method. Among the yield attributes, cob girth and 100 seed weight were not influenced either with irrigation or nitrogen and their interaction. Cob length, number of seeds row^{-1}, green cob and fodder yield were higher with drip irrigation of 120% E pan but were on par with 100% E pan. Among the different nitrogen levels, nitrogen at the rate of 240 kg ha^{-1}recorded significantly higher growth parameters, yield attributes, green cob and fodder yield but it was on par with 200 kg ha^{-1} and both were superior over 160 and 120 kg N ha^{-1}. Drip irrigation of 100% E pan and a nitrogen level of 200 kg ha^{-1} resulted in higher gross and net returns and benefit cost ratio compared to other irrigation and nitrogen treatments. From the study, drip irrigation of 100% E pan with 200 kg N $ha^{-1}$is recommended for getting higher yields and net income in sweetcorn hybrid grown in Southern Agro climatic zone of Telangana, India.

Keywords: Sweetcorn; post monsoon; drip irrigation levels; nitrogen levels; yield; Economics; Telangana.

1. INTRODUCTION

India being one of the leading maize producers worldwide, occupies significant position in the maize exports. Maize cultivation has a key role in India as it is a component of National food security programme [1]. In Telangana state, maize is the second most important crop after rice with an acreage of 14 lakhs and a production of 16 lakh tonnes [2]. As majority of the farmers are growing maize in rain fed condition resulting in frequent crop failures as maize is sensitive to both excess and deficit rainfall [3].

Sweet corn (*Zea mays* var. saccharata) is a specialty type of maize with 13 to 15 per cent sugar which can be consumed in the fresh form. It is becoming popular not only in India but also in other Asian countries. Keeping in view of its global demand, its cultivation in peri urban areas of different states of India is increasing and emerging as an important urbanite dish [4]. As the duration of the crop is only 80-90 days compared to normal maize of 110-120 days, it can be better cultivated in low rainfall areas and with limited irrigation also. Hence, its importance in peri urban areas is increasing [2].

In India, around 80 percent of the available water is utilized for irrigation [5]. As the majority of the groundwater sources in the country are registering a decline in water level, there is no other option except to use water judiciously in farming without foregoing the productivity. Hence, micro-irrigation is one of the choices left to address the water scarcity problem [5]. Drip irrigation is a type of micro irrigation method which helps in saving water by applying directly in the root zone of the crop and also allows application of fertilizer simultaneously. The state of Telangana is also promoting micro irrigation and offering unique subsidy pattern and providing 80 to 100 per cent subsidy under Telangana Micro Irrigation Project [5].

Poor nutrient management is one of the major factors resulting in low productivity of any crop [6]. Being the primary nutrient, nitrogen management offers a significant role in growth and development of maize [7]. Besides reducing the environmental pollution, yield productivity as well as nutrient use efficiency can be enhanced with optimum nitrogen application [8] and [9]. Ever-increasing price of nitrogen and reduction in subsidy on fertilizers have forced farmers to use fertilizers efficiently [10].

Realising the importance of judicious use of irrigation water and fertilizer nitrogen as both are very important resources in determining the productivity of any crop, fertigation method was adopted. Fertigation is the efficient and economical way of applying water as well as fertilizer precisely directly in the root zone of the plant [11]. Keeping all these in view, as not much research on fertigation aspects of sweet corn was done in the study centre of Maize Research Centre, the present experiment on “Performance evaluation of sweetcorn under different levels of irrigation and nitrogen through drip during post monsoon season at Rajendranagar, Hyderabad, India” was taken up.

2. MATERIAL AND METHODS

The research study was carried out for two years at Maize Research Centre, Agricultural Research

Institute, Rajendranagar, Hyderabad, Telangana, India during post monsoon season. The experimental field is geographically located with a longitude of 78° 28' East, latitude of 17°19' North and an altitude of 542.6 m above mean sea level and situated in Southern Telangana Agro Climatic zone of Telangana. As per the soil analysis, the soil was identified as clay loam, slightly alkaline with a pH of 7.8 having organic carbon of 0.38%, available nitrogen of 195.3 kg ha^{-1}, available phosphorus of 30.23 kg $ha^{-1}$and available potassium of 160.5 kg ha^{-1}.Randomized block design with factorial concept was selected to conduct the experiment in three replications. The treatments were two factors. Factor I was five irrigation levels viz., I_1: Drip irrigation at 60% E pan,I_2: Drip irrigation at 80% E pan, I_3:Drip irrigation at 100% E pan, I_4:Drip irrigation at 120% E pan andI_5: Surface irrigation at IW/CPE- 1.0 and Factor II was four nitrogen levels in kg ha^{-1} viz., N_1: 120, N_2: 160 N_3: 200 N_4: 240. Ridge and furrow method of irrigation was adopted as surface irrigation method. Evaporation data for scheduling of irrigation for $I_1$to I_4treatments was taken from Agro-meteorological station, Rajendranagar and it was fixed as once in two days. Haryana sweetcorn-1 hybrid (HSC-1) was used for the study. The crop was sown in October 25th in the first year and October 30th in the second year and harvested on January 15th (82 days) during first year and January 22nd (84 days) during the second year. Spacing adopted was 60x20 cm. All the standard package of practices like plant protection, weed management etc were followed as recommended by Professor Jayashankar Telangana State Agricultural University [2]. Nitrogen, phosphorous @ 80 kg ha^{-1} and potassium @ 80 kg ha^{-1}were applied as urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Total quantity of SSP and MOP were applied basally. Regarding the nitrogen, 20 kg ha^{-1} was applied uniformly to all the treatments as basal and remaining quantity was applied in ten equal splits through drip in I_1 to I_4treatments. In I_5 treatment, the rest of the nitrogen was applied in three equal splits. Data was analysed and interpreted as per Gomez and Gomez [12] technique of analysis of variance.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Pooled mean over two years indicated that, plant height in cm, Leaf Area Index (LAI) in % at harvest and dry matter production in g $plant^{-1}$ of sweetcorn hybrid was influenced significantly by both irrigation as well as nitrogen levels and their interaction (Table 1).

Among the irrigation levels, drip irrigation at 120% E pan recorded significantly higher plant height, LAI at harvest and dry matter production but it was on par with drip irrigation at 100% E pan and both were significantly superior over drip irrigation at 80 and 60% E pan and surface irrigation method. Different nitrogen levels had significant influence on plant height, LAI at harvest and dry matter production in the pooled mean over two years. Nitrogen at the rate of 240 kg ha^{-1} recorded significantly higher plant height, LAI and dry matter production which was on par with 200 kg $ha^{-1}$and both were significantly superior over 160 and 120 kg N ha^{-1}.Interaction between irrigation and nitrogen levels was found significant with respect to plant height, LAI and dry matter production of sweetcorn hybrid. Drip irrigation at 120% Epan with 240 kg N ha^{-1} exhibited significantly higher values for plant height (261 cm), LAI (5.38%) and dry matter production (409 g $plant^{-1}$) but they were on par with drip irrigation at 100% Epan with 200 kg N ha^{-1} (255, 5.26 and 381 respectively) and both were superior with other irrigation and nitrogen combinations.

Application of water and nutrients frequently throughout the crop growth according to the crop demand directly at the root zone is possible in drip fertigation. Due to this, water and nutrients were effectively utilized without loss of nutrients in leaching which is common in surface irrigation method. Hence, the crop might not have faced any nutrient stress which led to better accumulation as well as uptake of nutrients. This might be the reason for taller plants with a greater number of leaves and leaf area and dry matter production with frequent drip fertigation with higher levels of nitrogen. But in surface irrigation, as the number of split applications of nitrogen is less and quick depletion of soil moisture which is common in surface method of irrigation might be the reason for lesser efficiency in utilizing water as well as nitrogen leading to poor growth parameters. Similar kind of better crop growth performance with frequent and higher application of water and nitrogen was reported by Cox et al. [13]; Al-Kaisi and Yin, [14]; Singandhupe et al. [15] and Sampathkumar and Pandian [16].

Table 1. Plant height in cm at harvest, Leaf Area Index (LAI) (%) at harvest and Dry matter production in g plant^{-1} of sweet corn hybrid as influenced by different levels of irrigation and nitrogen levels(pooled mean over 2 years)

Treatments	Plant height (cm) at harvest					Leaf Area Index (LAI) (%) at harvest					Dry matter production (g plant^{-1})				
	N_1-120	N_2-160	N_3-200	N_4-240	Mean	N_1-120	N_2-160	N_3-200	N_4-240	Mean	N_1-120	N_2-160	N_3-200	N_4-240	Mean
I_1-Drip at 60% E Pan	216	220	231	234	225	3.23	3.61	4.30	4.33	3.87	192	222	256	261	233
I_2- Drip at 80% E Pan	225	224	239	243	233	3.52	3.93	4.58	4.69	4.18	213	253	287	295	262
I_3- Drip at 100% E Pan	230	238	255	254	244	4.01	4.72	5.26	5.29	4.82	238	314	381	390	331
I_4- Drip at 120% E Pan	232	241	256	261	248	4.37	4.87	5.34	5.38	4.99	254	326	397	409	347
I_5- Surface irrigation	219	221	231	236	227	3.31	3.53	4.07	4.19	3.78	165	200	227	230	206
Mean	224	229	242	246		3.69	4.13	4.71	4.78		212	263	310	317	
		S. Em±	CD (P=0.05)				S. Em±	CD (P=0.05)				S. Em±	CD (P=0.05)		
I		3.2	10				0.10		0.27			9		23	
N		3.0	8				0.10		0.29			7		20	
I x N		3.5	15				0.20		0.50			16		44	

3.2 Yield Attributes

Pooled mean over two years indicated that, cob girth in cm was influenced significantly by both irrigation and nitrogen levels but interaction was found non - significant whereas the effect of both irrigation and nitrogen levels and interaction was found non- significant in case of number of rows cob^{-1} and 100 seed weight in g (Table 2). Drip irrigation with E pan of 120% recorded significantly higher cob girth (14.51 cm) but it was on par with drip irrigation with 100% E pan (14.43 cm) and both were significantly superior over rest of the irrigation levels (13.86, 12.91 and 12.43 respectively). Nitrogen at the rate of 240 kg ha^{-1} was found significantly superior in terms of cob girth(14.23 cm) but it was on par with 200 kg N ha^{-1} (14.01 cm) and both were superior over the other nitrogen doses(13.59 and 12.65 respectively).

Pooled mean of two years indicated that, both irrigation and nitrogen levels and their interaction were found significant with regards to cob length in cm and number of seed row^{-1} (Table 3). Cob length and number of seed row^{-1}were significantly higher with an irrigation level of 120% E pan but it was on par with irrigation level of 100% Epan whereas irrigation levels of both 80 and 60% E pan and surface irrigation reported significantly lower values of cob length and number of seed row^{-1}. Among the nitrogen levels, nitrogen at the rate of 240 kg ha^{-1} (on par with 200 kg ha^{-1}recorded significantly higher values of both cob length and number of seed row^{-1} and both were superior with 160 and 120 kg N ha^{-1}.Interaction effect of irrigation and nitrogen levels indicated that, significantly superior values of cob length and number of seed row^{-1}were with drip irrigation of 120% E pan with 240 kg N ha^{-1} (24.2 cm and 41.7 respectively) but were on par with drip irrigation of 100% Epan with 200 kg N ha^{-1} (23.8 cm and 41.4 respectively) compared to other irrigation and nitrogen levels.

Availability of optimum soil moisture in the root zone with higher quantity of available water through drip might have facilitated the enhanced absorption of nutrients which lead to the production of more foliage and better partitioning of dry matter to the cob and the same was reflected in superior attributes of cob. Similar results were reported by Singandhupe et al. [15] and Sampathkumar and Pandian, [16].

3.3 Yield

The data of pooled mean over two years with regards to green cob in t ha^{-1}, and fodder yield in t ha^{-1} was presented in Table 3. Both irrigation and nitrogen levels and their interaction exhibited significance with respect to green cob and fodder yields of sweetcorn hybrid. Drip irrigation with Epan of 120% resulted in significantly higher green cob and fodder yields compared to drip irrigation of 100% E pan whereas drip irrigation of 80 and 60% Epan as well as surface irrigation of IW/ CPE of 1.0 recorded significantly lower values of green cob and fodder yields. Nitrogen at the rate of 240 kg ha^{-1} on par with 200 kg ha^{-1} recorded significantly higher green cob and fodder yields whereas significantly lower green cob and fodder yields are with 120 kg N ha^{-1}. Interaction effect showed that, drip irrigation of 120% E pan with 240 kg N ha^{-1} resulted in significantly higher green cob and fodder yields (15.0 and 33.4 t ha^{-1} respectively) which were on par with 100% E pan with 200 kg N ha^{-1} (13.7 and 31.4 respectively) and both were significantly superior over other irrigation and nitrogen combinations.

Sweetcorn crop might have responded well to the applied nitrogen with frequent and higher irrigation through drip as maize is highly responsive to nutrients and water. There might be a positive correlation between full irrigation level and yield attributing characters like cob length, cob girth and number of seeds row^{-1} compared to deficit irrigation levels as well as with surface irrigation which led to increased cob weight. Similar response in maize was already confirmed by Binder et al. [17]. Gencoglan and Yazar,[18]; Yazar *et al.,* [19] and Bozkurt *et al.,* [20] also confirmed higher corn grain yield with full irrigation compared to very low yields in less irrigation treatment. The results were also in conformity with Oktem et al., [2] who reported higher sweetcorn green cob yield of 13.66 t ha^{-1} with E pan of 100% in 2- day irrigation frequency with drip. Dali Wu, [21] also reported increased yield, improved efficiency of water and nutrients and greater economic returns with drip fertigation in maize.

3.4 Economics

Cost of cultivation, gross and net returns and benefit cost ratio of sweetcorn hybrid was influenced by both irrigation and nitrogen levels (Table 4).

Table 2. Cob girth in cm, number of rows cob^{-1} and 100 seed weight in g of sweet corn hybrid as influenced by different levels of irrigation and nitrogen levels (pooled mean over 2 years)

Treatment	Cob girth (cm)	Number of rows cob^{-1}	100 Seed weight(g)
Irrigation levels			
I_1-Drip at 60% E Pan	12.91	13.00	34.30
I_2- Drip at 80% E Pan	13.86	13.31	34.36
I_3- Drip at 100% E Pan	14.43	13.42	34.91
I_4- Drip at 120% E Pan	14.51	13.44	35.56
I_5- Surface irrigation	12.43	12.95	34.25
S. Em±	0.13	0.35	0.76
CD (P=0.05)	0.45	NS	NS
Nitrogen levels (kg N ha^{-1})			
N_1-120	12.65	12.87	33.93
N_2-160	13.59	13.24	34.39
N_3-200	14.01	13.35	34.90
N_4-240	14.23	13.43	35.44
S. Em±	0.12	0.32	0.55
CD (P=0.05)	0.40	NS	NS
Interaction			
S. Em±	0.50	0.60	0.93
CD (P=0.05)	NS	NS	NS

Plate 1. Overall field view of the experiment

Plate 2. Comparison between I_3 N_3 (Drip fertigation at 100% Epan and 200 kg N ha^{-1}) and I_4 N_1 (Drip fertigation at 120% Epan and 120kg N ha^{-1}) on growth of plant at knee high stage

Plate 3. Influence of drip irrigation @120% Epan with application of 200 and 240kg N ha^{-1} at knee high stage of sweetcorn

Plate 4. Comparision between I_4 N_4 (Drip fertigation at 120% Epan and 240 kg N ha^{-1}) and I_3 (Drip fertigation at 100% Epan and 200 kg N ha^{-1}) in green cobs of sweet corn

Table 3. Cob length in cm, number of seeds row^{-1}, green cob yield in t ha^{-1}and fodder yield in t ha^{-1}of sweetcorn hybrid as influenced by different irrigation and nitrogen levels (pooled mean over 2 years)

Treatments	Cob length (cm)					Number of seeds row^{-1}					Green cob yield (t ha^{-1})					Fodder yield (t ha^{-1})				
	N_1-120	N_2-160	N_3-200	N_4-240	Mean	N_1-120	N_2-160	N_3-200	N_4-240	Mean	N_1-120	N_2-160	N_3-200	N_4-240	Mean	N_1-120	N_2-160	N_3-200	N_4-240	Mean
I_1-Drip at 60% E Pan	21.2	21.7	22.5	22.6	22.0	35.9	37.2	37.9	38.1	37.3	6.9	7.9	9.1	9.3	8.3	16.0	17.4	19.0	20.4	18.2
I_2- Drip at 80% E Pan	22.0	22.5	23.4	23.4	22.8	37.0	38.5	39.7	40.0	38.8	8.2	9.2	10.8	10.2	9.6	19.6	22.0	24.0	24.9	22.6
I_3- Drip at 100% E Pan	22.5	23.2	23.8	24.0	23.4	38.1	39.5	41.4	41.4	40.1	9.2	10.3	13.7	14.2	11.9	21.9	26.1	31.4	32.8	28.1
I_4- Drip at 120% E Pan	22.8	23.7	24.1	24.2	23.7	38.3	39.8	41.6	41.7	40.4	9.7	10.3	14.3	15.0	12.3	23.2	27.3	32.2	33.4	29.0
I_5- Surface irrigation	20.7	21.9	23.2	23.5	22.3	32.9	35.7	39.6	39.9	37.0	6.2	6.9	8.2	8.2	7.4	14.2	15.8	17.2	18.0	16.3
Mean	21.8	22.6	23.4	23.5		36.4	38.1	40.0	40.2		8.0	8.9	11.2	11.4		19.0	21.7	24.8	25.9	
	S. Em+CD (P=0.05)					**S. Em+CD (P=0.05)**					**S. Em+CD (P=0.05)**					**S. Em+ CD (P=0.05)**				
I	0.23		0.5			0.30		1.0			0.31		0.9			0.61		1.8		
N	0.21		0.5			0.25		0.8			0.29		0.8			0.53		1.5		
I x N	0.51		2.5			0.50		1.5			0.67		1.8			1.08		3.1		

Table 4. Cost of cultivation in ₹ha^{-1}, gross returns in ₹ha^{-1}, net returns in ₹ha^{-1} and benefit cost ratio of Sweet Corn hybrid as influenced by plant densities and nitrogen levels (Pooled mean over 2 years)

Treatment	Cost of cultivation (₹ha^{-1})	Gross returns (₹ha^{-1})	Net returns (₹ha^{-1})	B:C ratio
Irrigation levels				
I_1-Drip at 60% E Pan	33,876	58,900	25,024	1.7
I_2- Drip at 80% E Pan	33,876	68,900	35,024	2.0
I_3- Drip at 100% E Pan	33,876	85,450	51,574	2.5
I_4- Drip at 120% E Pan	34,950	88,300	53,350	2.5
I_5- Surface irrigation	35,862	52,550	16,688	1.5
Nitrogen levels (kg N ha^{-1})				
N_1-120	34,868	57,500	22,632	1.6
N_2-160	35,355	64,250	28,895	1.8
N_3-200	35,876	79,600	43,724	2.2
N_4-240	36,675	81,350	44,675	2.2

Cost of green cobkg^{-1} = ₹6/-; Cost of stover kg^{-1} = ₹ 0.5/-

Among the irrigation levels, surface irrigation method registered higher cost of cultivation compared to drip irrigation treatments. Gross and net returns and benefit cost ratio (88,300 and 53,350 ₹ha^{-1} and 2.5 respectively) were higher with drip irrigation of 120 % E pan but were comparable with drip irrigation of 100 % E pan and (85,450 and 51,574 ₹ha^{-1} and 2.5 respectively) both were superior over the rest of the drip irrigation treatments as well as surface irrigation method. The results were in conformity with Vishwanatha et al. [22] and Ramah et al. [23]. Among the nitrogen levels, nitrogen at the rate of 240 kg ha^{-1} recorded higher gross and net returns and benefit cost ratio (81,350 and 44,675 ₹ha^{-1} and 2.2 respectively) but it was on par with nitrogen at the rate of 200 kg ha^{-1}(79,600 and 43,724 ₹ha^{-1} and 2.2 respectively). Sahoo and Mahapatra, [24]; Kar et al. [25] and Seema Sepat and Ashok Kumar, [26] also reported similar results.

4. CONCLUSION

From the study, it can be concluded that performance of sweetcorn hybrid was influenced significantly by both irrigation as well as nitrogen levels. Drip irrigation level of 120% E pan with 240 kg Nitrogen ha^{-}1 and 100% E pan with 200 kg Nitrogen ha^{-1} were comparable in getting higher yields and net income. But, keeping in view of improving the efficiencies of both water and fertilizer nitrogen, drip irrigation level of 100% E pan with 200 kg Nitrogen ha^{-1}can be recommended as the most economical way of growing sweetcorn to get maximum green cob yield and net profits in sweetcorn hybrid grown in Southern Agro climatic zone of Telangana state, India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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