

Effect of planting techniques and irrigation scheduling on productivity and water use efficiency of sweet corn (*Zea mays saccharata*)

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ABSTRACT

A field experiment was conducted at Pantnagar in spring of 2009 and 2010 to study the response of planting techniques and irrigation schedules on productivity and profitability of sweet corn (*Zea mays saccharata*). The experiment consisted of three planting techniques viz. flat planting, flat planting followed by earthing up at 25 days after sowing and ridge planting, and four irrigation schedules i.e. irrigation at 50, 75 and 100 mm CPE and crop critical growth stages (knee high, tasseling, silking and grain filling) was laid out at factorial randomized block design with three replications. The pooled results revealed that the increase in green cobs and fodder yields was 5.1 and 15.2% and 5.0 and 12.6% on ridge planted over flat + earthing up and flat planted sweet corn, respectively. Similarly ridge planting was found superior with highest water use efficiency and net profit. Among the irrigation schedules, irrigation at 75 mm CPE gave 5.9, 10.7 and 13.9% higher green cobs than irrigation scheduled at 50 mm CPE and 100 mm CPE and critical growth stages, respectively. Besides, ridge planting with irrigation scheduled at 75 mm CPE had the highest water use efficiency and net profit. It is therefore concluded that spring sweet corn may be planted on ridges and irrigation be scheduled at 75 mm CPE for higher productivity, profitability and water use efficiency.

Key words: Cumulative pan evaporation, Economics, Planting technique, Irrigation schedule, Sweet corn

Sweet corn is a new choice of the progressive farmers as its green cobs as well as nutritious green fodder fetch higher market prices, beside, it provides better option to fit into different cropping systems because it is a 70–75 days crop. Maize is very sensitive to both excess and deficit moisture, therefore, the planting techniques may play important role for its proper seedling establishment. Normally flat planting is common but it does not suite in high water table as well as heavy rainfall areas because of excess moisture. On contrary, the flat planting followed by earthing up has improved its grain and stover yield (Thakur *et al.*, 2003). Similarly, the ridge planting is another technique that is preferred for higher maize productivity due to better plant establishment, less weed infestation and higher water and nutrient use efficiencies (Memon *et al.*, 2007 and Kumar, 2008).

In spring season (February to May), the water requirement of the crop increases with increment in temperature, so precision water management may not only improve water use efficiency but also helps in better plant growth

and development by maintaining optimum soil moisture regime throughout the crop growing period with reduced environmental impact (Javaid and Khalid, 2009). Moisture stress leads poor plant stand and leaf area index resulting poor grain and fodder maize yield (Shafiq *et al.*, 2003), while excess moisture causes poor plant stand as well as stunted plant growth. Among different approaches of scheduling irrigation, use of cumulative pan evaporation (CPE) and water sensitive critical crop growth stages are simple and feasible (Shinde *et al.*, 2009). Therefore, the present field experiment was carried out to study the response of planting techniques and irrigation schedules on productivity, profitability and water use efficiency of sweet corn in *Tarai* belt of Uttarakhand.

MATERIALS AND METHODS

Field experiment was conducted at N E Borlaug Crop Research Centre, G B pant university of Agriculture & Technology, Pantnagar in spring of 2009 and 2010 to study the response of planting techniques and irrigation schedules on productivity and profitability of sweet corn. The experimental site with 29°N and 79.5°E and 243.8 m amsl falls under narrow belt of foot hills of Shivalaik range of Himalaya known as *Tarai* belt. The minimum and

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maximum mean temperature varied in 2009 and 2010 during field experimentation from 7.4 to 41.7°C and 10.1 to 40.6°C with relative humidity from 11 to 95 and 13 to 88%, respectively. The cumulative pan evaporation (CPE) was 670.5 and 683.9 mm in 2009 and 2010, respectively. The soil of the site was sandy loam in texture, neutral in reaction with pH 6.89 (Beckman Glass Electrode pH meter), 0.78% organic carbon (Walkely-Black modified method), 232.84 kg KMnO₄ oxidizable N/ha, 8.83 kg 0.5 N NaHCO₃ extractable P/ha and 194.0 kg 1.0 N NH₄OAc exchangeable K/ha.

The experiment consisted of three planting techniques viz. flat planting, flat planting followed by earthing up at 25 days after sowing and ridge planting, and four irrigation schedules i.e. irrigation at 50, 75 and 100 mm CPE and crop critical growth stages (knee high, tasseling, silking and grain filling) was laid out at factorial block design with three replications. The field was pre irrigated both years before planting the field experiment. The furrows were opened with furrow opener and ridges were made with the help of ridge maker at 60 cm spacing. The plot size 3.0 m × 5.0 m was made with provision of buffer channel of 1.0 m wide between plots as well as replications. The depth of irrigation was fixed 6.0 cm during both years and so the crop was irrigated 9, 6 and 4 times in 2009 and 8, 6 and 4 times in 2010 at 50, 75 and 100 mm CPE, respectively. The sweet corn 'NMH-123' was planted on 19th and 20th February at planting geometry of 60cm × 20cm and harvested on 27th and 25th May in 2009 and 2010, respectively. Fertilizer dose of 120-26.2-33.3 kg N-P-K /ha was applied to crop. Full dose of P and K and 1/3rd of nitrogen were applied at sowing and remaining nitrogen was top dressed in two equal splits one at knee high and another at tasseling stages. The pre-emergence herbicide Atrazine @ 1.0 kg ai/ha was applied followed by one hand weeding at 25 days after sowing to control the weeds. The insecticide Profenophos @3ml/l of water was sprayed at 50 DAS to control the *Heliothis* caterpillars.

The growth attributes like plant height, number of green cobs, cob length and cob girth were recorded at harvest of crop on randomly selected five plants from each treatments. The 50% tasseling and silking were recorded on the basis of 50% emergence of reproductive parts in the field. The plant population, cob yield, fodder yield were also recorded on net plot basis. The consumptive use of crop was calculated with standard methodology by estimating first soil profile evapotranspiration (ET) and then converted in to consumptive use ($cu = ET + 0.85 E_0$, where E_0 is value of pan evaporation). The ET_0 was estimated by using Modified Penman-Monteith equation (FAO, 1998). The water use efficiency (WUE) was estimated by dividing cob yield with total consumptive use of water. The

economics parameters like gross returns, net returns and benefit: cost ratio (B:C ratio) were calculated on the basis of prevailing prices of cobs and fodder.

RESULTS AND DISCUSSION

Growth and yield attributes

Among the planting techniques, the ridge planting produced significantly taller plants and shortest were measured under flat planting (Table 1). Similarly, the ridge planting also produced significantly higher number of green cobs with 3.0 and 9.0% higher than flat + earthing up and flat planting, respectively, however both ridge planting and flat + earthing up planting techniques had statistically equal number of green cobs. The cob length did not differ among planting techniques, however pooled data showed the highest cob length under flat + earthing up planting technique and lowest in flat planting technique. Ridge planted sweet corn had significantly higher cob girth that remained significantly similar to flat + earthing up planting technique. The ridge planting, in general, gave higher growth attributes mainly because of advantages of better aeration, least compaction, poor weed infestation, better seedling establishment, more nutrient uptake due to better root growth and also avoidance of water logging over flat planting (Bakht *et al.*, 2006, Menon *et al.*, 2007 and Kumar, 2008). The plant stand was recorded highest under ridge planting that remained statistically at par with flat + earthing up. The higher plant stand under ridge planting may be attributed to better seedling establishment and more favourable crop growing condition (Singh *et al.*, 2006)

Among the irrigation schedules, the highest plant height was recorded at 75 mm CPE, which was at par with irrigation applied at 50 mm and 100 mm CPE but significantly higher than irrigation at critical growth stages. Number of green cobs was recorded significantly highest at 50 mm CPE followed by 75 mm and 100 mm CPE and the lowest value was found when crop was irrigated at its critical growth stages. The higher number of green cobs was the result of higher plant stand at 50 CPE. The longest cobs were found at 75 mm CPE that remained non significant with 50 mm and 100 mm CPE. Similarly, the cob girth was recorded significantly higher at irrigation schedule at 75 mm CPE that had non significant values with 50 mm CPE. Irrigation scheduled at 100 mm CPE as well as critical growth stages had lower but significantly equal cob girth. The plant stand was recorded significantly higher at 50 mm CPE that remained statistically equal to 75 mm CPE and the lowest value was found at 100 mm CPE. The irrigation scheduled at 50 and 75 mm CPE with more irrigation might have maintained optimum soil moisture regime that resulted in to better plant growth and de-

velopment as well as yield attributes. Shafiq et al. (2003), Sangakkara *et al.* (2010) also supported above findings.

Green cob and fodder yields

Both planting techniques and irrigation schedules had significant effect on green cobs and fodder yields (Table 1). Among the planting techniques, ridge planted sweet corn produced 5.1 and 15.2 % higher green cobs than crop planted on flat + earthing up and flat planting, respectively. Similar trend was also observed for fodder yield as ridge planted crop produced significantly 4.5 and 12.6% higher green fodder yield than crop planted at flat + earthing up and flat, respectively. The higher yield of green cobs as well as fodder under ridge planting is mainly attributed to better plant stand and higher values of yield attributes and also supported by Galiakberov (2006).

The high frequency of irrigation at lower CPE had greater advantage over low frequency of irrigation at higher CPE values as evidenced with irrigation schedule at 75 mm CPE that had significantly highest green cob yield with 5.87, 10.70 and 13.9% higher than irrigation scheduled at 50 and 100 mm CPE and critical growth

stages, respectively. The cob yield was however recorded lower at 50 mm CPE than 75 mm CPE possibly due to unfavourable soil moisture regime in the field particularly for crop like maize that is very sensitive to both water-logged as well as drought conditions. Usman (2000) and Sangakkara *et al.* (2010) also observed higher yield under favourable soil moisture regimes. It is again evident that precise irrigation schedules gave more cob yield than crop irrigated at its critical growth stages mainly because of better plant stand as well as higher values of yield attributes. Variations in the fodder yield owing to irrigation schedules were also followed the similar pattern of cob yield and significantly highest and the lowest fodder yield were recorded at 75 mm CPE and critical growth stages, respectively.

Consumptive use and water use efficiency

Ridge planted sweet corn had significantly lowest consumptive use of water and the highest under flat planted sweet corn (Table 1). The consumptive use of water also varied with irrigation schedules and significantly highest value was recorded at 50 mm CPE followed by 75 mm

Table 1. Effect of planting techniques and irrigation schedules on growth, yield attributes, cob and fodder yields, consumptive use of water and water use efficiency of sweet corn in spring season (Pooled data of two years)

Treatment	Plant height (cm)	Plant stand ($\times 10^3$ /ha)	Number of green cobs ($\times 10^3$ /ha)	Cob length (cm)	Cob girth (cm)	Green cob yield (t/ha)	Fodder yield (t/ha)	Consumptive use (mm)	Water use efficiency (kg/ha-mm)
<i>Planting techniques</i>									
Flat	186	68.03	68.44	19.7	15.0	12.41	22.72	293	42.33
Flat + Earthing up	190	70.86	72.47	19.9	15.6	13.60	24.57	290	46.95
Ridge	194	72.33	74.67	19.6	16.0	14.30	25.78	283	50.46
SEm $\pm$	02	0.84	0.79	0.2	0.2	0.06	0.48	01	0.24
CD (P=0.05)	07	2.48	2.33	NS	0.5	0.18	1.42	03	0.71
<i>Irrigation schedule</i>									
50 mm CPE	191	73.16	74.48	19.7	15.9	13.60	24.61	298	45.64
75 mm CPE	195	71.23	73.94	20.1	16.3	14.41	26.45	294	48.93
100 mm CPE	188	68.08	69.98	19.9	14.8	13.04	23.84	284	45.88
Critical growth stages	185	69.16	69.03	19.3	15.0	12.71	22.54	278	45.86
SEm $\pm$	03	0.97	0.92	0.2	0.2	0.07	0.56	01	0.28
CD (P=0.05)	08	2.86	2.69	0.5	0.6	0.20	1.64	03	0.81

Table 2. Interaction effect of planting techniques and irrigation schedules on water use efficiency of sweet corn (Pooled data of two years)

Planting techniques	Irrigation schedules				
	50 mm CPE	75 mm CPE	100 mm CPE	Critical growth stages	Average
Flat	41.59	45.17	41.77	40.80	42.33
Flat + Earthing up	45.96	49.75	46.52	46.07	46.95
Ridge	49.88	51.87	49.36	50.72	50.45
Average	45.64	48.93	45.88	45.86	45.86
Planted technique		Irrigation schedule	Interaction		
SEm $\pm$	0.24	0.28	0.48		
CD (P=0.05)	0.71	0.81	1.41		

Table 3. Effect of planting techniques and irrigation schedules on economics of sweet corn in spring season (Pooled data of two years)

Treatment	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	B:C ratio	Net income (₹/day)
<i>Planting techniques</i>				
Flat	20.1	57.5	2.81	600
Flat + Earthing up	22.3	62.9	2.81	655
Ridge	20.7	68.8	3.31	717
SEm±	-	0.33	0.02	-
CD (P=0.05)	-	0.97	0.05	-
<i>Irrigation schedule</i>				
50 mm CPE	21.7	63.9	2.93	661
75 mm CPE	21.1	68.9	3.20	718
100 mm CPE	20.8	61.1	2.94	637
Critical growth stages	20.5	58.7	2.86	612
SEm±	-	0.38	0.02	-
CD (P=0.05)	-	1.12	0.05	-

*Selling price of green cobs @ ₹5/kg and fodder @ ₹700/tonne during both years.

CPE and the lowest when crop was irrigated at critical growth stages. The higher consumptive use was attributed to higher frequency of irrigation that resulted in to more availability of irrigation water for consumptive use.

Significantly the highest value of WUE was recorded at ridge planting that had 7.5 and 19.2 % greater values than flat + earthing up and flat planting techniques, respectively. The higher water use efficiency on ridge planted crop was attributed to effective water utilization by higher green cobs and also reduced consumptive use of water. Among irrigation schedules, crop irrigated at 75 mm CPE had significantly highest water use efficiency with 6.6 and 7.2 % higher than irrigation scheduled at 100 and 50 mm CPE, respectively. It indicates that more frequent irrigation at 50 mm CPE or lower than this CPE may not be beneficial to sweet corn production. Similar findings were also reported by Mallikarjunaswamy et al. (1999).

Economics

The flat + earthing up planting technique had maximum cost of cultivation mainly because of labour cost involved in manual earthing (Table 3). The gross returns, net returns and also benefit: cost ratio were recorded significantly the highest in ridge planting mainly because of more cob and fodder yield. The pooled analysis revealed that the ridge planting had nearly 9.4 and 19.5% greater net returns than flat + earthing up and flat planting techniques, respectively. The irrigation scheduled at 50 mm CPE had maximum cost of cultivation mainly due to high cost of water as well as more labour consumed in frequent irrigation. The gross returns, net returns and B:C ratio were recorded significantly highest at irrigation scheduled at 75 mm CPE mainly because of higher cob and fodder yield at 75 mm CPE. Similarly, the highest net income per

day was found when sweet corn was planted on ridges (₹717/-) compare to ₹655/- and ₹600/- under flat + earthing up and flat planting techniques, respectively. Similarly the sweet corn planted at 75 mm CPE had the highest net income per day followed by irrigation scheduled at 50 mm CPE and the lowest when the crop was irrigated at critical growth stages.

Interaction effect

The significant interaction between planting techniques and irrigation schedules indicated that the ridge planting had the highest water use efficiency under all irrigation schedules. Similarly, the water use efficiency was recorded significantly higher under flat + earthing up planting techniques than flat technique in all the irrigation schedules (Table 2). Flat planting technique had the lowest water use efficiency in all irrigation schedules. The ridge planting with irrigation scheduled at 75 mm CPE had significantly higher water use efficiency that remained non significant with ridge planting with irrigation scheduled at crop critical growth stages. Therefore, the ridge planting sweet corn with irrigation scheduled at 75 mm CPE had the highest water use efficiency.

Based on the study, it is concluded that spring season sweet corn should be planted on ridges and irrigated at 75 mm CPE for greater growth, productivity, profitability and water use efficiency.

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