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Spring sweet corn (*Zea mays*) response to irrigation levels, sowing methods and moisture conservation practices

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ABSTRACT

A field experiment was conducted during spring (February-May) of 2017-18 at GBPUAT, Pantnagar to assess the effect of irrigation levels, sowing methods and moisture conservation practices on soil moisture, crop growth, productivity of spring season sweet corn. The experiment consisted of 3- irrigation levels including irrigation at IW/CPE ratios of 1.0, 1.2, 1.4, 2- sowing methods (flat, furrow) and 3-moisture conservation practices (control, mulch @ 6 t/ha, biochar @ 3 t/ha) laid-out in a split-plot design, assigning combination of irrigation and sowing methods to main-plots and moisture conservation practices to sub-plots. The pooled results revealed that husked cob yield (15.79 t/ha) and biological yield (39.47 t/ha) of sweet corn were highest in IW/CPE 1.4 which were significantly higher than other two IW/CPE ratios. Furrow sowing resulted 8% increase in husked cob yield over flat sowing, while soil biochar application being at par with mulching showed significantly higher (6%) husked cob yield over control. The interaction effect showed that biological yield was at par between irrigation at IW/CPE 1.2 under furrow sowing and IW/CPE 1.4 under flat sowing. B: C ratio was higher with IW/CPE 1.4 (1.57), furrow sowing (1.54) and mulch (1.54). Higher soil moisture content before irrigation at tasseling stage was obtained under IW/CPE 1.4 (16.3%), furrow sowing (6.4%) and mulch (24.9%) as compared to IW/CPE 1.0, flat and control, respectively. Thus, sweet corn in sandy loam soil should be irrigated at IW/CPE 1.4, sown in furrows and supplemented with mulch or biochar application for enhancing productivity and profitability during spring season (February-May).

Key words: Biochar, B: C ratio, Flat sowing, Furrow sowing, IW/CPE, Mulch, Sweet corn

Sweet corn (*Zea mays* L. var. saccharata) is a hybridized variety of maize with higher kernel protein, low starch, high sugar content (14-25%), antioxidants, vitamins and minerals than the other maize types. Generally, sweet corn matures in 90-95 days during the spring season and thus increases the cropping intensity. Globally, over the last 25 years, the total production and value of processed sweet corn have increased by 60% (Williams 2006). Maize is generally grown in all the three seasons and several environmental, cultural and genetic factors influence maize yield and quality (Kumari *et al*. 2017). Spring season cultivation is advantageous due to less insect, pests, disease attack and better sunshine hours. However, the major constraints during spring season include high temperature and limited water supply. High temperature affects the vegetative and reproductive stages of sweet corn and causes reduction in grain filling. High evapo-transpiration (ET) during spring season demands for precise irrigation water management (Sharma and Dass 2012, Singh *et al.* 2016).

Several studies have indicated that besides scheduling of irrigation, inclusion of moisture management practices, viz. mulching, biochar and crop establishment methods like furrow sowing could enhance crop productivity in a profitable and sustainable manner (Sonpure *et al*. 2015, Arif *et al*. 2016). Furrow sowing can help to mitigate the severe water limitations by facilitating application of irrigation water directly to the root zone and reducing evaporation losses. Mulch has been proved very effective in regulating soil temperature, retaining water, reducing nitrate leaching, controlling weeds (Datta *et al*. 2017, Ghosh *et al*. 2017) improving soil physical properties and nitrogen balance (Sarolia and Bhardwaj 2012, Dass and Bhattacharyya 2017). Besides conserving moisture, biochar has capability of carbon sequestration, reducing soil compaction, nitrous oxide emission, improving soil physical condition and enhancing nutrient uptake from the soil (Lehmann 2007, Datta *et al*. 2018). Limited studies have been done combining irrigation levels, sowing methods and moisture conservation practices for spring sweet corn cultivation under *Tarai* belt. Hence, the present investigation was undertaken to find out the most suitable and sustainable techniques for increasing productivity and profitability of spring season sweet corn under sandy loam soil in *Tarai*

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belt of Uttarakhand.

MATERIALS AND METHODS

A two-year field experiment was conducted during spring season of 2017-18 at GBPUAT Pantnagar (29°N latitude and 79.5°E longitude and at an altitude of 243.83 m above mean sea level) to investigate the effect of irrigation levels, sowing methods and moisture conservation practices in spring sweet corn. The cumulative pan evaporation was 539 and 573 mm in 2017 and 2018, respectively. The rainfall received during the growing period was 35.8 mm (29.2 mm in the last week) and 48.1 mm, respectively during the two consecutive years. Soil was neutral in pH with high organic C (0.76%), low in available nitrogen (218 kg/ha), medium in available potassium (238 kg/ha) and available phosphorus (13 kg/ha).The experiment was conducted in a split-plot design with 3- irrigation levels (IW/CPE 1.0, 1.2 and 1.4) and 2- sowing methods (flat and furrow) allotted to main-plots, and 3-moisture conservation practices (control, mulch @ 6.0 t/ha and biochar @ 3.0 t/ha) allotted to sub-plots. Sugar 75 variety was sown @ 10 kg/ ha at 60 cm × 20 cm geometry. In case of furrow sowing, furrows (15 cm deep) were opened with tractor-drawn ridge and furrow maker and flat sowing was done in furrows (6 cm deep). Biochar was applied in prepared field prior to opening of furrows and mulch (loose rice straw) was applied within 1–2 days of sowing. The depth of irrigation was 6 cm under flat sowing and 4.5 cm in furrows. The height was measured with the help of meter scale from ground surface to tip of folded leaf whereas, it was measured from base to ligule of the upper most fully opened leaf after tasseling stage. For stem girth, the circumference of the stem was measured with a fine thread by holding it around the stem. The sun dried plant samples were dried in drier at 70+ 2ºC for obtaining the dry weight. The length of five cobs without husk was measured with the help of meter scale. A fine thread was used to record cob girth at three points, i.e. top, middle and bottom of cob. The cobs selected for individual cob weight were used for counting number of grain rows per cob. Number of grains per cob was computed as average number of grain rows per cob × average number of grains per row. The husked cob yield was recorded from the crop harvested from net plot area. The total biological yield was calculated by addition of green fodder yield and total husked cob yield. Benefit: cost (B:C) ratio was worked out on the basis of expenditure incurred on individual treatment and returns obtained from husked cob yield of different treatments. The mean soil moisture content before irrigation was calculated by gravimetric method. Data were analysed under split-plot design with two main-plot factors and one sub-plot factor with the help of computer software programme, OPSTAT statistical programme developed by HISAR (Sheoran *et al*. 1998). The analysis of variance was calculated for each parameters and the least significant di□erence (LSD) values were used to compare treatment means at P=0.05. The correlation between husked cob yield and soil moisture content was computed in SPSS software.

RESULTS AND DISCUSSION

Growth and yield attributes: Among the irrigation schedules, a significantly higher plant height was obtained at IW/CPE 1.4 as compared with the remaining ratios at 30 and 60 DAS. Also, a significant increase in stem girth was found with increase in IW/CPE levels from 1.0-1.2 and 1.2-1.4 (Table 1). Irrigation at IW/CPE 1.4 registered significantly higher dry matter accumulation as compared to the lower ratios in both study years. At 30 DAS, the plant dry matter at IW/CPE 1.4 was higher by 14.3% than 1.2 and by 38.8% over IW/CPE 1.0. The husked cob weight and grains/cob were the highest at IW/CPE 1.4 followed by 1.2. Relatively, more husked cob weight (Table 2) in IW/CPE 1.4 was mainly due to frequent application of water which helped in availability of higher soil moisture in the root zone. IW/CPE of 1.2 and 1.4 were found to be at par with each other and were significantly better than IW/CPE 1.0 with respect to cob length. Similarly, cob girth followed the same trend due to better partitioning of photosynthates to the reproductive parts. Reduced irrigation frequency resulted in poor plant growth in terms of plant height, stem girth and dry matter as a result of restriction imposed on nutrient translocation and metabolic activities of the plant (Asim *et al*. 2013, Dass and Chandra 2013).

Furrow planting produced significantly taller plants as compared to flat one; the same has also been observed by Kanakdurga *et al*. (2012). Furrow method of sowing resulted in an increase in stem girth and dry matter accumulation to

Table 1 Effect of irrigation levels, sowing methods and moisture conservation practices on growth parameters of sweet corn (mean of two years)

Treatment	Plant height (cm)		Stem girth (cm)		Dry matter (g/m^2)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Irrigation level (IW/CPE ratio)						
1.0	59.2	135.5	5.8	7.8	111.3	447.7
1.2	67.0	144.2	6.4	8.7	135.2	687.8
1.4	73.8	150.6	7.0	9.2	154.5	927.6
SEm±	1.0	1.2	0.1	0.1	2.1	10.0
CD 5%	3.3	3.8	0.3	0.3	6.6	31.5
Sowing method						
Flat	64.1	140.9	6.3	8.4	126.7	613.7
Furrow	69.2	146.0	6.6	8.7	140.6	761.7
SEm±	0.8	1.0	0.1	0.1	1.7	8.2
CD (P=0.05)	2.7	3.1	0.2	0.3	5.4	25.7
Moisture conservation practice						
Control	61.3	134.8	6.0	8.2	116.8	516.6
Mulch (6 t/ha)	69.5	147.3	6.6	8.7	141.9	772.5
Biochar (3 t/ha)	69.3	148.3	6.6	8.7	142.4	774.0
SEm±	1.1	1.2	0.1	0.1	2.8	18.9
CD (P=0.05)	3.1	3.6	0.2	0.2	8.2	55.2

the tune of 3.6 and 24.1% at 60 DAS, which was significantly higher as compared to flat sowing (Table 1). The husked cob weight recorded under furrow method was 297 g/cob, whereas in flat method it was 271 g/cob. Cob girth followed the similar trend as that of cob length with the highest value for furrow planting which was significantly superior to flat sowing. The higher moisture availability under furrow sowing led to improved physiological process in sweet corn which eventually resulted in higher photosynthates accumulation and better translocation. Sonpure *et al*. (2015) also reported similar findings.

Mulch and biochar stood at par with respect to plant height at both observation dates. The stem girth was significantly lower in no moisture conservation plots than mulch and biochar applied plots (Table 1). A higher dry matter accumulation was recorded in biochar plots followed by mulched plots, which could be attributed to reduction in soil moisture loss due to evaporation and better soil health. Favourable effect of biochar on dry matter production of maize have also been reported by Situmeang *et al*. (2017) and that of mulch by Sindhu *et al*. (2007). Situmeang *et al*. (2017) reported that biochar @10 t/ha led to an increase in the total oven dry weight of corn plant (509.31 g), which was 23.9% more when compared with no biochar (410.90 g). Sindhu *et al*. (2007) observed that mulch improved maize biomass by 22% over unmulched mulch plots due to wheat straw application @6 t/ ha. The higher husked cob weight was recorded in biochar plots, i.e. 290 g (5.5% higher than control) followed by mulched plots, i.e. 288 g (4.7% higher than control). Mulch and biochar significantly increased cob length and girth over control (Table 2). Inferior cob length under control might be due to poor moisture conservation and higher ET during April-May. Biochar application resulted in significantly higher number of grains/cob (605) and was at par with mulch application (581). Mulch application reduces evaporation losses, hinders weed germination and moderates soil temperature in root zone which contributes to overall plant growth. Biochar improves the soil conditions, retains nutrient and moisture and supplies them throughout the growing period of the crop.

Yield and B:C ratio: There was a marked increase in husked and biological yield (Table 2) under higher irrigation levels and significantly higher yield increment was recorded under IW/CPE 1.4 (15.79, 39.47 t/ha) which was significantly superior to IW/CPE 1.2 (15.29, 38.05 t/ha) and 1.0 (13.52, 33.85 t/ha). Possible reasons might be the availability of adequate moisture which resulted in increased photosynthates diversion from source to sink. Increasing yield response with increasing irrigation levels have also been reported by Bandyopadhayay and Mallick (2003) and Bozkurt *et al*. (2011). Harvest index remained unaffected due to varied irrigation levels. The B:C ratio under IW/CPE 1.4 (1.57) and 1.2 (1.51) were found to be at par with each other. Furrow establishment registered 7.8 and 7.4% more husked cob yield and biological yield over flat sowing. Since, irrigation was applied in the furrow, thus, higher moisture regime was created in the root zone which curtailed evaporation losses and met the crop water requirement. Furrow method of sowing increased the B:C ratio significantly over flat method and the increment was 14.1%.

Mulch application recorded 5% higher biological yield

Table 2 Effect of irrigation levels, sowing methods and moisture conservation practices on yield attributes, yield and B: C of sweet corn (mean of two years)

Treatment	Husked cob weight (g)	Cob length (cm)	Cob girth (cm)	Rows per cob	Grains/ row	Grains/ cob	Husked cob yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	B: C
Irrigation level (IW/CPE ratio)										
1.0	258	17.0	15.5	14.2	36.8	531	13.52	33.85	29.01	1.26
1.2	292	19.2	15.9	14.8	37.7	576	15.29	38.05	28.99	1.51
1.4	303	19.1	16.2	15.1	39.1	608	15.79	39.47	29.16	1.57
SEm±	2	0.2	0.1	0.2	0.2	7	0.12	0.28	0.20	0.02
CD (P=0.05)	6	0.6	0.3	NS	0.5	22	0.39	0.89	NS	0.06
Sowing method										
Flat	271	18.1	15.7	14.5	37.4	555	14.31	35.81	29.31	1.35
Furrow	297	18.8	16.1	14.9	38.3	588	15.43	38.45	28.80	1.54
SEm±	2	0.2	0.1	0.2	0.1	6	0.10	0.23	0.16	0.02
CD (P=0.05)	5	0.5	0.3	NS	0.4	18	0.32	0.73	NS	0.05
Moisture conservation practice										
Control	275	18.1	15.6	14.4	36.7	530	14.34	35.86	28.68	1.52
Mulch (6 t/ha)	288	18.6	16.0	14.8	38.0	581	15.04	37.65	29.22	1.54
Biochar (3 t/ha)	290	18.7	16.0	14.8	38.8	605	15.22	37.86	29.27	1.28
SEm±	3	0.2	0.1	0.2	0.2	6	0.13	0.31	0.27	0.02
CD (P=0.05)	8	0.5	0.4	NS	0.6	17	0.39	0.89	NS	0.06

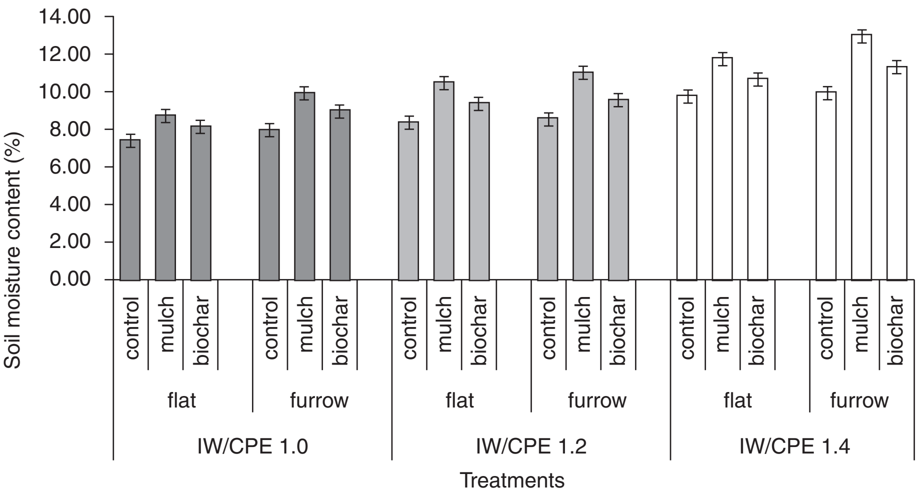

Fig 1 Effect of various irrigation levels, sowing methods and moisture conservation practices on soil moisture content (%) before irrigation at tasseling stage.

control due to better soil moisture retention and increased yield. The lower B:C ratio obtained with biochar could be ascribed to higher cost of biochar production. However, improved soil health, C-sequestration, reduced leaching of nutrients with biochar application, if converted into monetary terms would provide higher returns in terms of much desired ecological sustainability. Interaction between treatment combinations, irrigation levels and sowing methods was found to be significant with respect to biological yield (Table 3). IW/CPE 1.4 flat and IW/CPE 1.2 furrow were at par with each other. The highest biological yield was obtained with treatment combination IW/CPE 1.4 under furrow sowing. IW/CPE 1.4 and 1.2 were significantly different under furrow sowing and at par with each other under flat sowing.

Table 3 Interaction effect between irrigation levels and sowing methods on biological yield of sweet corn (mean of two years)

Irrigation levels (IW/CPE)	Sowing method	
	Flat	Furrow
1.0	31.69	36.02
1.2	37.52	38.58
1.4	38.21	40.73
SEm± 0.40	CD (P=0.05) 1.26	

than no mulch whereas, biochar application increased yield by about 6% over control. Straw mulch minimizes evaporation losses by slowing the energy exchange at the soil surface and has been confirmed in earlier reports by Singh *et al*. (2016). Mulch recorded numerically higher B:C than

Soil moisture content: The mean soil moisture content recorded before irrigation at tasseling stage was higher at IW/CPE 1.4 which was followed by IW/CPE 1.2 and 1.0. (Fig 1). The increase in soil moisture content, over control at IW/CPE 1.4 was 16.3% higher as compared to IW/CPE 1.2. Furrow method resulted in greater soil moisture retention than flat beds as water was applied directly to the root zone and evaporation was reduced to a considerable amount. Higher amount of water retention was recorded under mulch which was followed by biochar. Under mulched plots, the increase in soil moisture content was 24.9% over control. The highest soil moisture was retained in the treatment IW/CPE 1.4 sown under furrow method and applied with mulch. The husked cob yield was positively correlated with soil moisture content and followed the regression equation

$$y= -0.153x^2 + 3.765x -6.863,$$

where, y, Husked cob yield; x, soil moisture content (Fig 2).

Thus, in Northern India spring sown sweet corn in a sandy loam soil should be sown in furrows and irrigated at IW/CPE 1.4 (irrigation requirement 9–10). For further moisture conservation, use of mulch @6 t/ha or biochar @3 t/ha is suggested.

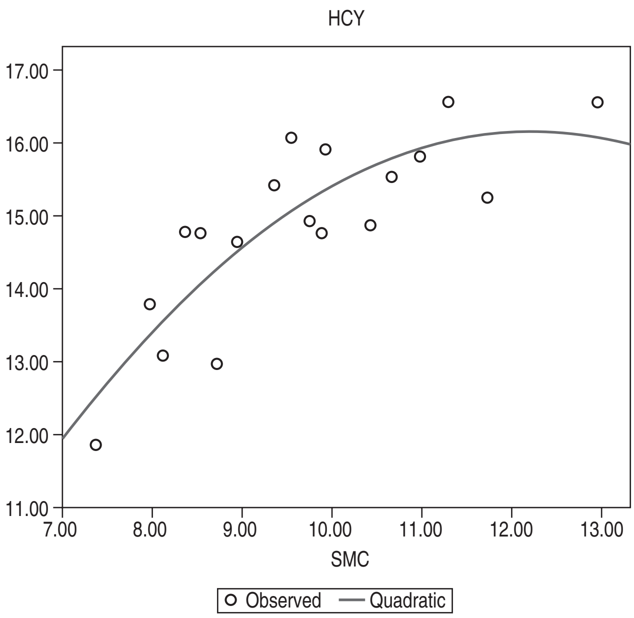

Fig 2 Correlation between soil moisture content (%) and husked cob yield (t/ha).

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