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Response of scheduling of irrigation with mulch under different planting methods on cane and water productivity in sugarcane

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Abstract
The aims of correct irrigation scheduling are to produce the optimum yield and to apply water efficiently. An experiment was conducted during 2016-17, 2017-18 and 2018-19 at research farm of Genda Singh Sugarcane Breeding and Research Institute, Seorahi, Uttar Pradesh under AICRP on sugarcane. The experiment consist of four combination of planting methods and mulching practices i.e. (P_1) conventional flat planting 75 cm row spacing with organic mulch @6 t/ha, (P_2) conventional flat planting 75 cm row spacing without mulch, (P_3) paired row trench planting 120:30 cm row spacing with organic mulch @ 6 t/ha and (P_4) paired row trench planting 120:30 cm row spacing without mulch and three irrigation schedule (IW/CPE) with irrigation water depth 7.5 cm i.e. I_1- 0.60, I_2- 0.80 and I_3- 1.00 were tested in strip plot design with three replications. Recommended dose of N:P:K ratio was 180:80:60 kg per hectare and applied before onset of monsoon. The experimental field was medium in organic carbon, medium in available phosphorus and low in potash with pH 8.15. Sugarcane variety CoSe 11453 was planted in spring season. The experimental findings on the basis of pooled data of three years showed that paired row trench planting 120:30 cm row spacing with organic mulch @ 6 t/ha recorded significantly higher germination per cent (56.18), shoot population (166.20 thousand ha^{-1}), NMC (124.46 thousand ha^{-1}) and cane yield (106.59 t/hectare) over remaining treatments of planting methods except paired row trench planting 120:30 cm row spacing without mulch treatment. Lowest cane yield (72.85 t ha^{-1}) was obtained in conventional flat planting 75 cm row spacing without mulch. Irrigation scheduling IW/CPE 1.0 ratio recorded significantly higher germination (53.10 per cent), shoot population (164.89 thousand ha^{-1}), NMC (116.76 thousand ha^{-1}) and cane yield (101.85 t ha^{-1}) over remaining irrigation scheduling. Sucrose per cent was not affected significantly due to different treatments of irrigation schedules and planting methods. Water productivity was recorded maximum in paired row 120:30 cm spacing trench planting with organic mulch @6t/ha (7.04 q/ha-cm) and 6.47 q/ha-cm in IW/CPE ratio 1.0 irrigation schedule.

Keywords: Mulch, Irrigation, Scheduling, CPE ratio, Planting, Water

Introduction
India is the world's largest sugar consumer and the second largest producer. The livelihoods of almost 35 million people are dependent on sugarcane production and it is grown on over 4.1 million hectares within the country. However, productivity is highly variable from state to state but cane productivity of Uttar Pradesh is 80.42 t/ha. Sugarcane is one of the most important cash crops of India grown under varied agro meteorological conditions ranging from tropical to subtropical climate. Majority of the area under sugarcane has to undergo severe stress conditions during January to June due to the hot summer and depletion of ground water sources. Water stress conditions during the formative phase affect the cane growth and quality. Water is the most crucial input for sugarcane production. Efficient management of water for sugarcane crop involves reduction in water losses in conveyance and distribution system through periodic maintenance, applying the right quantity at right time, right cultivation techniques and irrigation practices including increased use of surface and ground waters and moisture conservation practices. Present era needs various ways of enhancing use efficiency and productivity of water in sugarcane production. These include: better utilization of stored soil moisture by adjusting time and method of sowing, improved planting patterns reducing

evaporation loss of soil moisture by mulching, intercropping, supplemental and deficit irrigation provided to crops at critical growth stages, removal of nutrient constraints by supplying optimum fertilizer inputs and improved irrigation schedule. The water requirement of sugarcane in India varies widely from 1143 to 3048 mm (Hapase *et al*., 1990) [5]. Another agronomic method for increasing water use efficiency is to follow proper planting techniques. Under adequate water availability the main emphasis is on securing potential yield of the crops without wasting water. Scheduling of irrigation was determined using a crop water demand model that took account of precipitation and crop requirements. The intervention focused on introducing improved water management practices to reduce water use in parallel with improved crop practices to increase crop yield (Singh *et al*. 2017a; Singh *et al*. 2017b; Singh *et al*. 2017c; Singh *et al*. 2018; Tiwari *et al*. 2018; Tiwari *et al*. 2019a; Tiwari *et al*. 2019b; Kour *et al*. 2019; Singh *et al*. 2019) [12, 13, 14, 15, 16, 17, 18, 19, 20].

Sandhu *et.al*. 1980 [10] reported that insufficient soil moisture and excessively high soil temperatures are reported to restrict growth of crops during the hot, dry months of April–June, conducted experiment to evaluate the effects of three irrigation schedules based on ratios of 0.50, 0.75 and 1.00 times pan evaporation, and two levels of paddy straw mulch of 0 and 6 tons/ha on yield and quality of sugarcane for a sandy loam. Cane yield increased by an average of 13.8% for the 1.00 over the 0.50 times pan evaporation. These beneficial effects were attributed to better soil moisture and temperature regimes with mulching. Irrigation and mulching had no effect on the quality of cane juice. These results indicate that straw mulching and early season irrigation to sugarcane based on 1.00 times pan evaporation is a promising practice for increasing sugarcane production in subtropical areas. Hence, keeping this in view the present study was carried out on response of scheduling of irrigation with mulch under different planting methods on cane and water productivity in sugarcane.

Materials and Methods

The soil of experimental site was calcareous with moderately alkaline in reaction with pH 8.15. The experiment consist of four combination of planting methods and mulching practices i.e. (P_1) conventional flat planting 75 cm row spacing with organic mulch @6 t/ha, (P_2) conventional flat planting 75 cm row spacing without mulch, (P_3) paired row trench planting 120:30 cm row spacing with organic mulch @ 6 t/ha and (P_4) paired row trench planting 120:30 cm row spacing without mulch and three irrigation schedule (IW/CPE) with irrigation water depth 7.5 cm i.e. I_1- 0.60, I_2- 0.80 and I_3- 1.00 were tested in strip plot design with three replications. Recommended dose of N:P:K ratio was 180:80:60 kg per hectare and applied before onset of monsoon. The experimental field was medium in organic carbon, medium in available phosphorus and low in potash. Sugarcane variety CoSe 11453 was planted in spring season. Sources of nitrogen, phosphorus and potash were urea, single super phosphate and muriate of potash, respectively. The total average rainfall received during crop growth period of 2016-17, 2017-18 and 2018-19 was 1238.72 mm. The maximum temperature was ranged between 21.30 to 32.43, 16.49 to 34.9 and 14.42 to 36.16 celsius whereas minimum temperature ranged between 6.94 to 25.41, 6.28 to 25.90 and 5.5 to 24.83 celsius in 2016-17, 2017-18 and 2018-19 crop periods, respectively. The improved crop management practices were followed during experimentation periods. Shoot population and number of millable cane were recorded from each net plot and the data were computed in thousands on hectare basis. The crop was harvested from ground level and green and dry leaves were stripped off. The weight of millable cane from each net plot was recorded and calculated on hectare basis. Filtrated juice was taken in a 20 ml of polarimeter tube to record pol reading with the help of polarimeter following Horne's dry lead Acetate Method as described by Spencer and Meade (1955) [23]. Schmitz's table was used to calculate juice sucrose. The economics were worked out based on three years pooled cane yield data and considering Uttar Pradesh state advisory price (SAP) of cane. The cost of cultivation was worked out by considering the current price of the input and commodity used. Cost of cultivation was subtracted from gross income to get net income. The benefit cost ratio was calculated on the basis of net returns obtained and cost of cultivation incurred. The techniques of analysis of variance (ANOVA) prescribed for strip plot design was used to test significance of the differences among treatments mean by the 'F' test. Water productivity is calculated by ratio of cane yield and total water use during the crop periods.

Results and Discussion

Effect of Planting method with mulch or without on cane productivity, juice and economics

In **Table 01** showed that effect of planting method observed significantly variation on germination (56.18 per cent), shoot population (166.20 thousand ha^{-1}) and number of millable cane (124.46 thousand ha^{-1}) by (P_3) paired row trench planting 120:30 cm row spacing with organic mulch @6t/ha except (P_4) paired row trench planting 120:30 cm row spacing without organic mulch. Difference between (P_1) conventional flat planting 75 cm row spacing with organic mulch @6 t/ha and (P_2) conventional flat planting 75 cm row spacing without mulch on germination, shoot population, NMC and cane yield was noted non-significant but comparison between conventional and paired trench planting method resulted significant higher germination percent, shoot population, NMC and cane yield in trench planted methods. Response of planting methods with or without mulch on sucrose percent was noted non-significant but maximum value (18.49 per cent) obtained in (P_3) paired row trench planting 120:30 cm row spacing with organic mulch @6 t/ha. 14.50 And 6.54 per cent increased the cane yield due to mulch in conventional and trench planting method, respectively**.** Saini and Singh (1985) [9] noted non-significant effect of irrigation levels on juice per cent. Over shading and mutual competition among plants are reasons for lower productivity of sugarcane grown through conventional method. Paired row trench planting method of sugarcane helps in generation of greater proportion of mother shoots and primary tillers that are responsible for higher yield and better quality. Bhullar *et al.* (2008) [2] conducted an experiment on flat, paired-row trench-and pit planting methods in sugarcane and reported that trench planting recorded the highest number of shoots and millable canes. Singh (2012) [22] also observed significantly higher tiller count in paired row planting. Cost of cultivation was recorded maximum (Rs. 139002 ha^{-1}) in P_3 and minimum (Rs. 131450 ha^{-1}) in conventional flat planting 75 cm row spacing without mulch (P_2). Paired row trench planting 120:30 cm row spacing with organic mulch @6t/ha practice produced significantly more net income (Rs. 196749 ha^{-1}) and B:C ratio (1.41) over remaining combination of planting methods but at par with paired row trench planting 120:30 cm row spacing

without organic mulch practice.

Effect of irrigation scheduling on cane productivity, juice and economics

Table 01 showed that scheduling of irrigation had significant impact on germination, shoot population, NMC and cane yield. IW/CPE ratio 1.0 produced significantly higher germination (53.10 per cent), shoot population (164.89 thousand ha^{-1}), NMC (116.76 thousand ha^{-1}) over all the IW/CPE ratio treatment but at par with 0.80 due to sufficient moisture availability during the critical period. Response of IW/CPE ratio on cane yield was recorded significantly higher (101.89 t ha^{-1}) in 1.0 IW/CPE ratio as against remaining IW/CPE ratio treatments. The cost of cultivation per hectare was higher (Rs.137824 ha^{-1}) under IW/CPE ratio 1.0 than 0.6 (Rs. 132628 ha^{-1}) and 0.80 (Rs. 135226 ha^{-1}). Gross income, net income and B:C ratio were increased significantly with each successive increase in IW/CPE ratio from 0.6 to 1.0. Irrigation scheduling IW/CPE ratio 1.0 produced significantly higher gross income (Rs.320941 ha^{-1}), net income (Rs. 183117 ha^{-1}) and B:C ratio (1.33) over remaining IW/CPE ratio practice. Bharad *et al.* (1991) observed that sugarcane crop receiving irrigation at 0.7, 0.75 and 1.0 IW/CPE ratio cane yield of 58, 79.9 and 88.9 t ha^{-1}, respectively. Gulati *et al.* (1995) [4] noted higher cane yield with irrigation at 1.2 IW/CPE ratio than that of 0.8 IW/CPE ratio. Sharma and Verma (1996) [11] reported that crop receiving irrigation 0.8 IW/CPE ratio gave significantly higher cane yield over the 0.5 IW/CPE ratio. Jadhav *et al.* (1997) [6] observed significantly higher cane yield at 1.0 IW/CPE ratio. Toor *et al.* (1999) [24] noted that sugarcane crop irrigated at 1.5 IW/CPE ratio produced significantly higher number of millable canes and cane yield than that of irrigated at 0.375, 0.3 and 0.25 IW/CPE ratios. Puttavenkategowda and Nagaraja (2015) [8] noted that scheduling of irrigation with mulch under different planting methods had significant influence on sugarcane yield. Gulati and Nayak (2002) [3] also concluded that cane yield and water requirement were maximum at 1.2 IW/CPE. Singh and Brar (2015) [21] also reported that the cane yield, sugar yield and net returns increased significantly and successively with increase in frequency of irrigation from 0.5 to 1.0 IW: CPE ratio.

Effect of Planting method and irrigation scheduling on water productivity

On the basis of three years pooled data in **Table 02** showed that paired row trench planting 120:30 cm row spacing with organic mulch @ 6t/ha (P_3) practice recoded maximum water productivity (7.04 q/ha-cm) followed by (P_4) paired row trench planting 120:30 cm row spacing without mulch (6.68 q/ha-cm), (P_1) conventional flat planting 75 cm row spacing with organic mulch @ 6 t/ha (5.56 q/ha-cm) and (P_2) conventional flat planting 75 cm row spacing without mulch (4.82 q/ha-cm). The lowest water use in IW/CPE ratio 0.60 (146.38 ha-cm) and maximum water applied in IW/CPE ratio 1.0 (161.38 ha-cm). IW/CPE ratio at 1.0 applied more water i.e. only 4.88 per cent from 0.8 IW/CPE ratio and 10.25 per cent from 0.60 IW/CPE ratio but IW/CPE ratio 1.0 recorded more water productivity i.e. 12.33 per cent from IW/CPE 0.60 and 11.36 per cent from 0.80 IW/CPE ratio.

Table 1: Response of combination of planting methods and Irrigation schedule (IW/CPE) productivity (Pooled data of three years)

Treatments	Germination (%)	Shoots (000/ha)	NMC (000/ha)	Cane yield (t/ha)	Sucrose (%)	Cost of cultivation (Rs.)	Gross income(Rs.)	Net income(Rs.)	B:C ratio
Planting methods									
P_1	43.24	146.33	102.80	83.42	18.28	136790	262770	125980	0.92
P_2	43.19	144.75	98.94	72.85	18.22	131450	229489	98039	0.74
P_3	56.18	166.20	124.46	106.59	18.49	139002	335751	196749	1.41
P_4	54.08	161.26	120.54	99.85	18.31	133662	314529	180867	1.35
CD(P=0.05)	2.96	12.28	8.65	5.63	NS	-	17792	17792	0.13
CV %	5.21	6.88	6.72	5.40	1.21	-	5.40	10.25	10.43
Irrigation schedules									
I_1	44.94	142.87	104.57	82.23	18.16	132628	259025	126397	0.95
I_2	49.48	156.15	113.73	87.92	18.28	135226	276939	141713	1.04
I_3	53.10	164.89	116.76	101.89	18.54	137824	320941	183117	1.33
CD(P=0.05)	3.66	7.44	3.84	1.14	NS	-	22501	22501	0.17
CV %	6.56	4.27	3.03	6.95	2.60	-	6.95	13.20	13.23

Table 2: Effect of combination of planting methods and Irrigation schedule on sugarcane water productivity (Pooled data of three years)

Treatments	Irrigation water applied (mm)	Total rainfall (mm)	Total water applied (cm)	Cane yield (q/ha)	Water productivity (q/ha-cm)
Planting methods					
P_1	300.00	1238.77	153.88	834.20	5.56
P_2	300.00	1238.77	153.88	728.51	4.82
P_3	300.00	1238.77	153.88	1064.64	7.04
P_4	300.00	1238.77	153.88	1011.01	6.68
Irrigation schedules					
I_1	225.00	1238.77	146.38	822.30	5.76
I_2	300.00	1238.77	153.88	879.15	5.81
I_3	375.00	1238.77	161.38	1028.25	6.47

Conclusion

On the basis of above investigation, it may be concluded that paired row trench planting 120:30 cm row spacing with organic mulch @6t/ha practice produced significantly higher germination per cent, shoot population, NMC and cane yield over conventional flat planting 75 cm row spacing with organic mulch @6t/ha and conventional flat planting 75 cm row spacing without mulch practices but among the irrigation scheduling, IW/CPE 1.0 ratio produced significantly higher performance. Sucrose per cent was not affected significantly with different treatments of planting methods and irrigation schedules. Cane yield and sucrose per cent increased with

increase the IW/CPE ratio.

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