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A study on the performance on productivity of sugarcane crop with different combination of tillage operations

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■ **ABSTRACT :** A field experiment was conducted to test the intensification and productivity of sugarcane (*Saccharum officinarum* L.*)* for two consecutive years (2014-15 to 2015-16) at Amroha district of Uttar Pradesh, India. Different sugarcane planter and conservative tillage practices were taken as different variables for experiments. Two irrigation treatment I_1 (Pre planting irrigation) and I_2 (Post planting irrigation); two tillage treatment T_1 (Conventional tillage) and T_2 (Rotavator) followed by five planting treatment P_0 (Conventional practice), P_1 (Disc type sugarcane planter), P_2 (Slit type sugarcane planter), P_3 (Ridger type sugarcane planter) P_4 (Furrower type sugarcane planter) were performed and tested under RBD (Factorial 2 x 5 x 2) with three replications. Pre irrigation treatments showed better results as compared to post irrigation with most promising with conventional method of tillage. Although treatment T_7 ($I_1P_3T_1$) yields with the highest values of bud germinations (50.37 and 51.71%) at 60 DAP, cane girth (9.31 and 9.67 cm), single cane weight (1.72 and 1.96 kg), cane yield (1074.67 and 1235.53 q/h^{-1}). It was concluded that the mechanized planting system requires less labour and is more frugal than the conventional one.

■ **KEY WORDS :** Sugarcane, Irrigation, Tillage, Cane yield, Planter

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Sugarcane occupies a very prominent position on the agricultural map of India covering astronomically immense areas in sub-tropics and tropics. It is the sole raw material for the most immensely colossal agro-processing industry in the rural sector, wherein about 6.0 million growers cultivate this crop. Majority of them are minute and marginal with minutely minuscular land holdings and 50 per cent of the total area under sugarcane is comprised of holdings between 0.5 to 5 ha. For 20.7 per cent of the area, holding size ranges between 5 to 10 ha. This has provided a unique advantage for better land use through intercropping and increase in the input use efficiency. High value and remunerative crops like vegetables, potato, oilseeds and pulses offer great scope for growing as intercrops and in further providing additional income and reducing risks in the long duration crop of sugarcane as well as in improving land use efficiency (Kumar and Rathinam, 2015)

India is the second largest producer of sugarcane in the world accounting for 10 per cent of the world production. Sugarcane is one of the best commercial crop. In India around 392 million hectares are under sugarcane cultivation with an annual production of about

170 million tones with productivity of 58/ha (Inbaraj and Jacob Stanley, 2015)

Moisture stress is one of the major constraints in productivity of sugarcane. More than 50% loss in the yield of sugarcane has been recorded due to drought (Vasantha *et al.*, 2005). Nearly 60% of the total sugarcane fields in India suffer from water stress, especially during summer. Water stress during this formative phase affect final cane yield due to reduction in tiller production, number of millable canes, individual cane weight, cane height and girth (Naidu and Venkataramana, 1988 and Pawar and Bhukhtar, 2011).

METHODOLOGY

Description of the study site, field conditions, equipments and measuring instruments:

Amroha district, previously known as Jyotiba Phule Nagar, is one of the 75 districts of Uttar Pradesh state in northern India, in the western region of Uttar Pradesh with an area of about 2249 Sq. kms. The district is divided into 1133 villages, 3 tehsils, 6 blocks and 11 police stations. Extending from latitute 28° 54' north to 39° 6' north and Longitude 78° 28' east to 78° 39'east. The maximum and minimum heights from sea level are 240ft. and 177ft., respectively. The district is bounded on the north by Bijnor district, on the east and southeast by Moradabad district, on the south by Badaun district, and on the west by the river Ganges, across which lkie Bulandshahar, Ghaziabad and Meerut districts. On account of high population pressure in Amroha district, more than 78 per cent of the reporting area has been brought under cultivation in the district which is high as compared to the proportion of net cultivated area at the state level (69 %). Despite higher proportion of net area sown in the district, cropping intensity has remained quite low (153 ha in Amroha district versus 193.08 ha in the state) which indicates that traditional structure of agriculture has not changed much in the district despite the fact that level of irrigation in the district has been far better than what could be in the state as a whole.

Sugarcane can be planted by different methods of planting like, deep furrow, trench method, ring pit method and paired row method instead of furrow system. According to methods of planting, four types of the sugarcane cutter planters having ridger, slit, furrower and disc furrow openers were used for conducting the experiment (Table B).

Experimental details and layout plan :

Two experiments were conducted in Fauladpur village, of Dhanaura Block in Amroha district of Uttar Pradesh state to achieve the performance and effects on production of sugarcane, using different sugarcane planter after wheat harvesting (Table C).

Table A : Physico-chemical properties of experimental fields

Sr. No.	Particulars	Soil depth			
		0-15 cm		15-30 cm	
		2014-15	2014-15	2015-16	2015-16
1.	**Mechanical composition**				
	Coarse sand (%)	0.56	0.55	0.53	0.54
	Fine sand (%)	59.10	59.32	59.88	60.58
	Silt (%)	25.27	26.78	25.00	26.88
	Clay (%)	15.13	14.73	15.28	14.48
	Textural class	Sandy Loam		Sandy Loam	
2.	**Physical properties**				
	Field capacity (%)	17.50	17.50	17.25	17.50
3.	**Chemical properties**				
	EC (1:2.5) (dsm^{-1})	0.26	0.25	0.24	0.25
	Soil pH (1:2:5)	7.50	7.55	7.60	7.65
	Organic carbon (%)	0.38	0.37	0.36	0.34
	Available N (kg ha^{-1})	199.5	203.2	189.7	188.3
	Available P_2O_5 (kg ha^{-1})	32.17	32.47	30.35	31.28
	Available K_2O (kg ha^{-1})	289.0	286.3	292.3	295.2
	Sulphur (ppm)	17.7	18.5	15.8	16.7

Table B : Technical specifications of sugarcane cutter planters

Sr. No.	Particulars	Specification			
	Type of furrow opener	Ridger	Disc	Furrower	Slit
1.	Source of power	Tractor	Tractor	Tractor	Tractor
2.	Power transmission	P.T.O.	Ground wheel	P.T.O	Ground wheel
3.	Capacity of insecticide tank, l	16	20	100	25
4.	Capacity of fungicide tank, l	16	22	40	30
5.	Capacity of fertilizer box, kg	25	35	45	30
6.	Row to row spacing, cm	Adjustable within 75.0-90.0	Adjustable within 75.0-90.0	Adjustable within 60.0-75.0	Adjustable within 75.0-90.0
7.	Capacity of seed box, kg	125	124	130	126

Table C : Treatment details

Sr. No.	Particulars	Symbol
Irrigations (I)		
1.	Pre- planting irrigation	I_1
2.	Post-planting irrigation	I_2
Planters (P)		
1.	Conventional practice (Tractor operated ridger) (control)	P_0
2.	Disc type sugarcane cutter planter	P_1
3.	Slit type sugarcane cutter planter	P_2
4.	Ridger sugarcane cutter planter	P_3
5.	Furrower type sugarcane cutter planter	P_4
Tillage (T)		
1.	Conventional tillage (1ploughing + 2 harrowing)	T_1
2.	Tillage operation by rotary tiller(2 rotavator)	T_2

Crop performance parameters for different treatments :

Bud germination :

The numbers of shoots per plot were counted at 60 days interval after sugarcane planting and per cent germination was worked out as follows:

$$\text{Per cent germination } Z \frac{\text{Number of shoots per plot}}{\text{Number of bud per plot}} \times 100$$

Cane girth (cm) :

Girth measurement was taken from 20 sample stalks selected randomly from the middle two rows. Measurement was made using Vernier caliper on three points of the stalks (upper, middle and bottom part of the stalk) after removal of the sheath.

Single cane weight (kg) :

The ten canes used for recording the length and girth were further used for determining the weight of individual cane with the help of spring balance and average value were determined.

Cane yield (q ha^{-1}) :

Harvesting of each experimental plot was done at maturity. Green and dry leaves were stripped off and weights of canes were recorded with the help of platform balance and yield was worked out on hectare basis.

Statistical analysis:

The data recorded during the course of investigation were subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level. For testing the hypothesis, the following ANOVA table was used (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of irrigation :

Data presented in (Table 1) indicated results of the experiment which revealed that the highest value was observed in treatment effect of the irrigation (I_1) on the *viz.*, that bud germination (40.70 and 43.54 %) at 60 DAP, cane girth (8.76 cm and 8.92 cm), single cane weight (1.59 and 1.74 kg), cane yield (922.41 and 1032.99 q h^{-1}) in treatment, (I_1) Pre-planting irrigation for the years 2014-15 and 2015-16, respectively.

Table 1 : Influenced by different irrigation, planters and tillage treatments on sugarcane during year (2014-15) and (2015-16)

Treatments		Bud germination (%) at 60 DAP		Cane girth (cm)		Single cane weight (kg)		Cane yield (q h^{-1})	
		2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Irrigations (I)									
I_1	Pre- planting irrigation	40.70	43.54	8.76	8.92	1.59	1.74	922.41	1032.99
I_2	Post-planting irrigation	40.50	42.68	8.74	8.94	1.56	1.66	884.37	981.64
	F-test	NS	NS	NS	NS	NS	NS	NS	NS
	S.E. ±	13.64	12.72	0.93	0.68	0.25	0.32	161.47	202.50
	C.D. (P = 0.05)	-	-	-	-	-	-	-	-
Planters (P)									
P_0	Conventional practice (Tractor operated ridger) (control)	38.24	42.55	8.69	8.88	1.49	1.63	886.59	968.55
P_1	Disc type sugarcane cutter planter	40.36	44.22	8.56	8.73	1.66	1.69	920.56	982.31
P_2	Slit type sugarcane cutter planter	40.95	42.03	8.82	9.00	1.55	1.67	911.02	988.87
P_3	Ridger sugarcane cutter planter	44.10	45.46	8.91	9.14	1.63	1.78	932.05	1067.25
P_4	Drum sugarcane cutter planter	39.35	41.32	8.76	8.90	1.55	1.73	866.75	1029.59
F-test		NS	NS	NS	NS	S	NS	NS	NS
S.E. ±		8.63	8.04	0.59	0.43	0.16	0.20	102.12	128.07
C.D. (P = 0.05)		-	-	-	-	0.46	-	-	-
Tillage (T)									
T_1	Conventional tillage (1ploughing + 2 harrowing)	40.39	43.78	8.80	8.97	1.57	1.72	909.72	1025.27
T_2	Tillage operation by rotary tiller(2 rotavator)	40.81	42.44	8.70	8.89	1.58	1.68	897.07	989.36
F-test		NS	NS	NS	NS	NS	NS	NS	NS
S.E. ±		13.64	12.72	0.93	0.68	0.25	0.32	161.47	202.50
C.D. (P = 0.05)		-	-	-	-	-	-	-	-
Interaction (PxI)									
F-test		NS	NS	NS	NS	NS	NS	S	NS
S.E. ±		6.10	5.69	0.42	0.30	0.11	0.14	72.21	90.56
C.D. (P = 0.05)		-	-	-	-	-	-	206.73	-
Interaction (PxT)									
F-test		NS	NS	NS	S	NS	NS	NS	NS
S.E. ±		7.47	6.96	0.51	0.37	0.14	0.17	88.44	110.91
C.D. (P = 0.05)		-	-	-	1.06	-	-	-	-
Interaction (IxT)									
F-test		S	S	S	S	S	S	S	S
S.E. ±		9.65	8.99	0.66	0.48	0.18	0.22	114.17	143.19
C.D. (P = 0.05)		27.62	25.74	1.89	1.37	0.51	0.64	326.87	409.93

NS=Non-significant

However, non-significant highest value of cane girth (8.94 cm) was observed in treatment, (I_2) (Post-planting irrigation) for the years 2015-16.

This might be due to in sugarcane, germination denotes activation and subsequent sprouting of the vegetative bud, the germination of bud is influenced by the external as well as internal factors, the external factors are the soil moisture, soil temperature and aeration. The internal factors are the bud health, sett moisture, sett reducing sugar content and sett nutrient status (Tarimo and Takamura, 1998). The germination (shoot emergence from soil) is a critical event in the plant life to assure a good harvest and it is initially dependent on the set nutrients and water, developing its own root system after about three weeks, under proper conditions (Divino and Victor, 1997). The crop establishment phase and formative phase (sprouting, tillering and grand growth stages, have been identified as the critical water demand period (Ramesh, 2000). This is mainly because 70-80% of cane yield is produced during this phase (Duli *et al.,* 2010). Water shortage results a negative impact on establishment of the crop, especially if the drought duration exceeds the capacity of drought tolerance of the plant species (Smit and Singels, 2006 and Inman-Bamber and Smith *2*004).

The result indicated that, 91-93% of the sugarcane sett buds were not sprouting during the delayed of first irrigation for 8 days after planting and only 7-10% were emergent in extremely scattered manner in all sugarcane varieties. Of the total un-sprouting sett buds, almost all of the sett buds did not develop root system and were highly dehydrated (shrinked). This showed that, out of the various factors that influence sprouting of sugarcane sett buds under field conditions, water content of the soil is very important for sugarcane establishment. Therefore, maintaining optimum moisture during the crop establishment period may be useful for obtaining optimum cane yield in drought areas (Hagos *et al.,* 2014).

Table 2 : Interaction effect of the planters on the bud germination (%) at 60 DAP, cane girth (cm), single cane weight (kg) and cane yield (q h^{-1}) during both years

Treatments		Bud germination (%) at 60 DAP		Cane girth (cm)		Single cane weight (kg)		Cane yield (q h^{-1})	
		2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1	$I_1P_0T_1$	37.33	43.90	8.99	9.26	1.48	1.58	872.03	932.46
T_2	$I_1P_0T_2$	43.73	43.93	8.36	8.43	1.62	1.65	991.37	1017.77
T_3	$I_1P_1T_1$	34.53	44.00	8.44	8.54	1.67	1.68	885.33	984.44
T_4	$I_1P_1T_2$	38.53	43.13	8.62	8.78	1.68	1.69	896.33	985.21
T_5	$I_1P_2T_1$	37.93	38.67	8.71	8.89	1.47	1.66	836.33	954.97
T_6	$I_1P_2T_2$	41.60	43.80	8.70	8.87	1.60	1.80	939.20	1060.57
T_7	$I_1P_3T_1$	50.37	51.71	9.31	9.67	1.72	1.96	1074.67	1235.53
T_8	$I_1P_3T_2$	40.00	43.17	8.73	8.76	1.63	1.83	941.70	1061.57
T_9	$I_1P_4T_1$	41.70	41.73	8.78	8.80	1.50	1.74	886.83	1033.37
T_{10}	$I_1P_4T_2$	41.23	41.40	8.91	9.15	1.51	1.77	900.35	1064.00
T_{11}	$I_2P_0T_1$	34.40	43.57	8.74	8.93	1.47	1.74	886.56	1048.40
T_{12}	$I_2P_0T_2$	37.50	38.80	8.65	8.91	1.40	1.53	796.40	875.57
T_{13}	$I_2P_1T_1$	43.70	44.53	8.60	8.72	1.70	1.73	977.80	1002.87
T_{14}	$I_2P_1T_2$	44.67	45.20	8.58	8.89	1.59	1.64	922.78	956.73
T_{15}	$I_2P_2T_1$	42.97	44.20	8.89	8.97	1.53	1.63	939.72	998.45
T_{16}	$I_2P_2T_2$	41.30	41.43	8.99	9.28	1.58	1.60	928.83	941.50
T_{17}	$I_2P_3T_1$	44.75	45.11	8.86	9.17	1.57	1.67	884.07	1007.93
T_{18}	$I_2P_3T_2$	41.30	41.83	8.73	8.95	1.61	1.66	827.75	963.97
T_{19}	$I_2P_4T_1$	36.23	40.40	8.67	8.77	1.63	1.80	853.83	1054.27
T_{20}	$I_2P_4T_2$	38.23	41.73	8.69	8.86	1.54	1.61	825.97	966.70
F-test		S	NS	NS	S	NS	NS	S	S
S.E. ±		4.31	4.02	0.29	0.21	0.08	0.10	51.06	64.04
C.D. (P = 0.05)		12.35	-	-	0.61	-	-	146.18	183.33

NS=Non-significant

The germination-ability decreased as the soil moisture was reduced, although a dependence of the response to cultivars ranged from 10 to 59 % (Yang and Chauhan, 1980). Superior germination of cane irrigated at planting and loss of germination with delayed irrigation has been reported in Hawaii. The need for moisture to trigger the shift of the bud from dormancy to activity could explain why setts irrigated at planting to have the highest germination percentages (Humbert, 1968). Delaying first irrigation after planting for more than three days will result in poor germination and unsatisfactory crop stands (Abayomi *et al.*, 1990).

Effect of planters:

Table 1 indicated that the bud germination (44.10 and 45.46 %) at 60 DAP, cane girth (8.91 and 9.14 cm), single cane weight (1.63 and 1.78 kg), cane yield (932.05 and 1067.25 q h^{-1}) differs non significantly in treatment (P_0) conventional practice (Tractor operated ridger) (control) for years 2014-15 and 2015-16, respectively.

This may be due to sugarcane coming directly in contact with blade center. In this design, cutting was smooth as evident from clean cut obtained. However, feeding rate was labour dependent, which may have caused variation in length of setts.

Effect of tillage:

The results (Table 1) of the experiment revealed that non significantly the highest value was observed in treatment effect of the tillage on the *viz.*, bud germination (40.93 and 43.78 %) at 60 DAP, cane girth (8.80 and 8.97 cm), single cane weight (1.57 and 1.72 kg), cane yield (909.72 and 1025.27 q h^{-1}) in treatment (T_1) conventional tillage (1 ploughing + 2 harrowing) for the years 2014-15 and 2015-16, respectively. However, non significantly the highest value of bud germination (43.78 %) at 60 DAP, single cane weight (1.58 kg) in treatment, (T_2) tillage operation by rotary tiller (2 rotavator) for the years 2015-16, respectively.

Interaction effect :

Table 2 shows that results attributes bud germination at 60 DAP, cane girth single cane weight cane yield were found non-significant during both years by interaction effect of planters with irrigation (PxI) except cane yield during 2014-15 and significantly the highest in interaction of irrigation and tillage (IxT).

The highest values for bud germination (50.37 and 51.71 %) at 60 DAP, cane girth (9.31 and 9.67 cm), single cane weight (1.72 and 1.96 kg), cane yield (1074.67 and 1235.53 q h^{-1}) had been observed by interaction effect of planters with irrigation (PxI) in treatment (T_7) $I_1P_3T_1$ pre- planting irrigation + ridger sugarcane cutter planter + conventional tillage (1ploughing + 2 harrowing) during the years 2014-15 and 2015-16, respectively.

The reason might be the adequate supply of moisture favorably improved nutrient uptake and translocation which ultimately is linked with the growth and development. Beneficial effects of these parameters resulted in to higher cane yield. Other reason for increasing cane yield might be due to the fact that the crop receiving irrigation at early growth stage established its root system deep into the soil for better extraction of moisture from larger volume of soil. The results are in agreement with Malavia *et al.* (1988); Singh and Dixit (1989) and Bhalerao (2001).

Conclusion :

After two years of observation with different tillage treatments, the highest cane yield was observed in treatment T_7 under treatment combination $I_1P_3T_1$ 1074.67 and 1235.53 q ha^{-1} during 2014-15 and 2015-16, respectively, this is might be due to mainly on favorable response of sugarcane to the pre- planting irrigation, ridger sugarcane cutter planter and Conventional tillage (1ploughing + 2 harrowing).

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