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Irrigation and fertigation scheduling effect on phenology and yield of spring sugarcane (*Sachharum officinarum*)

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to evaluate better irrigation water supply with nitrogen fertilization scheduling option to achieve maximum yield of spring planted sugarcane (*Sachharum officinarum* L.). Experiment was laid out in split plot design. The treatment consisted of three irrigation methods, viz. flood, furrow and drip; five nitrogen scheduling, viz. farmers practice, 4 splits, 6 splits, 8 splits and 10 splits. Results of the study indicated that higher number of tillers, leaf area index, number of millable canes and cane stalk yield were found under drip irrigation as compared to flood and furrow irrigation. Drip irrigation increase 22.30% cane stalk yield than irrigation through flood method. Significantly highest phenological growth, yield attributing characters and cane stalk yield were recorded with 6 splits of nitrogen application. Nitrogen application through farmers practice reduced 8.83 and 9.56% cane yield during two consecutive years, respectively. The overall effect of nitrogen application scheduling was in the order of 6 splits > 8 splits >10 splits >4 splits >farmers practice.

Key words: Cane yield, Irrigation methods, Nitrogen scheduling, Split application

Sugarcane (*Saccharum* spp.) is the largest part of agricultural economy of India which is produced to fulfill the demand of sugar, jaggery and khandsari. India has topmost position regarding production of sugarcane in the world. Sugar manufacturing is the second prevalent agro based industry in the country with significant contribution towards earnings, employment and tax revenue of the rural area (Priya *et al.* 2015). Sugarcane production in India is 362.33 million ton with 71.5 t/ha productivity. Uttar Pradesh state produced highest cane yield (36.73%) among all states of India (Anonymous 2017). It requires thousand liters of water to produce one kilogram sugar. However, a large area in northern India faces shortage of water mainly in summer season due to insufficient irrigation facilities (Archana 2016). India has the favorable climatic conditions for cane cultivation but experiencing some limitations, viz. faulty water management techniques and fertilization or nourishment of crop according to requirement. Due to lack of suitable technique sugarcane productivity is still lower in India. Irrigation management with appropriate nitrogen fertilization scheduling agrees to increase in production as well as productivity of sugarcane. Nitrogen supplement therefore by split application becomes important as it is supplied ideally in a time, when crop critically requires. Hence, critical stages of nitrogen requirement can be better met with split applications. Early nitrogen application resulted in lower sugarcane yield, while the late fertilizer application resulted in lower sugar production due to decrease cane juice quality rather than any loss in growth (Wiedenfeld 1997). Application of nitrogen in splits increased the fertilization cost, but it was justified by increased sugarcane yield.

Drip fertigation is one of the most potential technology, offers the immense capacity to increase cane yield up to 200-220 t/ha (Senthil Kumar 2009), irrigation water saving of 40-50% and increase nutrient efficiency by 40% (Solomon 2012). The present investigation was therefore, conducted to explore the production of spring planted sugarcane with appropriate irrigation methods and standardize nitrogen fertilization schedule through splitting.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during spring season of 2016-17 and 2017-18. The soil of the experimental site is categorized as sandy clay loam in texture with 58.90% sand, 22.45% silt and 18.65% clay. The soil was low in organic carbon and available nitrogen, medium in available phosphorus and potassium. Annual rainfall (1239.2 mm) received during first crop season and 649 mm during second year.

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The experiment was conducted in split plot design with four replications. Treatments keeping three method of irrigation in main plot, viz. I_1 (flood irrigation), I_2 (furrow irrigation), I_3 (drip irrigation) and five nitrogen fertilization scheduling, viz. N_1 (50% basal + 50% on commencement of monsoon), N_2 (4 splits at 30 days interval), N_3 (6 splits at 20 days interval), N_4 (8 splits at 15 days interval) and N_5 (10 splits at 10 days interval) in sub plot. Split application started after 30 days of planting (except in N_1). The sugarcane crop was planted in first week of March during both the seasons. Planted setts were two budded vigorous and treated with 0.25% solution of Emisan. The recommended dose of fertilizers, 180 kg N, 80 kg P_2O_5 and 60 kg K_2O were applied through Urea, single super phosphate and muriate of potash, respectively. Full amount of P_2O_5 and K_2O fertilizers were applied as basal and N application was done as per scheduling. The crop harvesting was done manually during the last week of January in each year followed by de-trashing and de-topping and fresh weight of cane stalk, cane top and cane trash were taken. The commercial cane sugar percentage (CCS%) was calculated by using the juice brix and sucrose (%) juice.

The fiber per cent was observed through rapipol method and calculated by using the formula described by Meade and Chen (1977). Leaf area index of sugarcane crop was taken by using the method proposed by Bhathia and Sharma (1978). The leaf area duration is the integral of leaf area index over a period of time and found out with the following formula suggested by Power *et al.* (1967).

RESULTS AND DISCUSSION

Growth parameters: Growth parameters of sugarcane were significantly influenced by irrigation methods (Table 1 and 2). Drip irrigation (I_3) resulted higher germination (55.74%) at 45 DAP in pooled data two consecutive years of experimentation. The results (Table 1) revealed that I_3 (drip irrigation) recorded significantly higher number of tillers (16.12 at 120 DAP), over I_1 (flood irrigation) and I_2 (furrow irrigation). This might be due to better water availability to sugarcane plants and favorable soil conditions for plant growth. These observations were in agreement with the findings of Chen *et al.* (2012). Among nitrogen scheduling, data showed that at 120 DAP significantly higher number of tiller was recorded by N_3 (6 splits) over N_1 (farmers practice) which were statistically at par with N_4 (8 splits), N_5 (10 splits) and N_2 (4 splits). This might have been due to better nutrition effect on crop and need based supply of nutrient. These findings are also supported with observation recorded by Padmanabhan *et al.* (2017). The data pertaining to leaf area index, leaf area duration and chlorophyll content (Table 1) revealed that (I_3) drip irrigation recorded significant increase over I_1 (flood irrigation) and I_2 (furrow irrigation) at different growth stages of crop growth in pooled analysis of two years of study. This might be due to higher plant height, maximum number of tillers and maximum SPAD value. The similar results were given by Silva *et al.* (2007) and Mahendran and Dhanalakshmi (2003). Nitrogen fertilization scheduling was also significantly affect the leaf area index, leaf area duration and chlorophyll content (SPAD value) of sugarcane at different growth stages.

Higher value of data revealed that significantly highest value was recorded under N_3 (6 splits) as compared to N_1 (farmers practice) and which were at par with N_4 (8 splits),

Table 1 Effect of irrigation methods and nitrogen scheduling on phenology of sugarcane at different growth stages (pooled data of two years)

Treatment	Germi-nation (%) at 45 DAP	Tillers (meter/ row length)	Leaf area index				Leaf area duration (days)			Chlorophyll content (SPAD value)			
			90 DAP	150 DAP	210 DAP	270 DAP	90-150 DAP	150-210 DAP	210-270 DAP	90 DAP	150 DAP	210 DAP	270 DAP
Irrigation methods													
I_1 : Flood irrigation	54.80	13.41	2.38	3.08	4.33	5.05	234.86	314.42	410.94	52.65	55.75	54.20	51.95
I_2 : Furrow irrigation	54.88	13.99	2.44	3.13	4.47	5.32	240.31	322.07	428.10	52.99	56.13	54.57	52.48
I_3 : Drip irrigation	55.74	16.12	2.76	3.55	5.15	5.91	272.26	367.22	486.21	54.24	57.52	55.75	53.22
SEm±	1.06	0.36	0.06	0.08	0.12	0.15	5.71	7.75	10.89	0.34	0.37	0.33	0.40
CD (P=0.05)	NS	1.25	0.21	0.26	0.41	0.53	19.75	26.83	37.70	1.17	1.27	1.14	NS
Nitrogen scheduling													
N_1 : Farmers practice	55.63	13.42	2.35	3.02	4.25	5.00	231.86	308.76	404.65	52.23	55.39	53.92	52.17
N_2 : 4 split	55.17	14.44	2.52	3.26	4.63	5.40	250.72	334.29	439.80	53.27	56.47	54.82	52.28
N_3 : 6 split	54.90	15.01	2.63	3.36	4.86	5.65	256.65	347.20	461.25	53.94	56.95	55.36	53.11
N_4 : 8 split	55.28	14.90	2.57	3.32	4.78	5.56	253.82	342.52	453.45	53.69	56.78	55.12	52.83
N_5 : 10 split	54.70	14.77	2.56	3.30	4.73	5.52	252.67	340.09	449.60	53.33	56.75	54.98	52.38
SEm±	0.97	0.32	0.06	0.07	0.11	0.12	4.69	6.77	8.84	0.30	0.34	0.28	NS
CD (P=0.05)	NS	0.91	0.17	0.20	0.31	0.33	13.45	19.41	25.36	0.87	0.97	0.81	0.96

Table 2 Effect of irrigation methods and nitrogen scheduling on yield attributes, yield and quality of sugarcane (pooled data of two years)

Treatment	Internodes (number/ cane)	Internodes length (cm)	NMC (meter/row length)	Cane weight (kg/cane)	Cane yield (t/ha)	Cane tops yield (t/ha)	Cane trash yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	CCS (%)	Fiber (%)
Irrigation methods											
I_1 : Flood irrigation	21.97	24.59	11.49	1.46	137.2	21.1	13.1	171.4	80.0	15.28	13.64
I_2 : Furrow irrigation	22.08	25.92	11.83	1.49	143.5	22.0	13.7	179.2	80.0	15.26	13.71
I_3 : Drip irrigation	23.31	28.57	13.51	1.63	167.8	24.8	15.2	207.9	80.7	14.81	13.78
SEm±	0.59	0.70	0.30	0.03	3.23	0.46	0.26	3.37	0.40	0.18	0.11
CD (P=0.05)	NS	2.42	1.03	0.12	11.19	1.58	0.89	11.67	NS	NS	NS
Nitrogen scheduling											
N_1 : Farmers practice	21.86	23.97	11.34	1.43	139.7	21.3	13.1	174.0	80.2	15.24	13.64
N_2 : 4 split	22.48	26.12	12.18	1.51	149.1	22.4	13.9	185.4	80.4	15.09	13.67
N_3 : 6 split	22.84	27.87	12.73	1.58	153.8	23.3	14.4	191.5	80.2	15.04	13.80
N_4 : 8 split	22.53	27.06	12.61	1.57	152.8	23.1	14.3	190.2	80.2	15.11	13.76
N_5 : 10 split	22.56	26.76	12.53	1.55	152.2	23.1	14.2	189.6	80.1	15.09	13.67
SEm±	0.52	0.40	0.26	0.03	2.67	0.40	0.22	2.66	0.38	0.14	0.10
CD (P=0.05)	NS	1.15	0.75	0.09	7.66	1.15	0.63	7.64	NS	NS	NS

N_5 (10 splits) and N_2 (4 splits). Increase phenological character due to profuse growth and better management of nitrogen application. These findings are in conformity with findings of Sreewarome *et al.* (2007) and Padmanabhan *et al.* (2017).

Yield attributes: Yield attributes of sugarcane, viz. internode length, cane weight and number of millable cane increased significantly with drip irrigation treatment as compared to flood and furrow method of irrigation. However, number of internodes per millable canes was not significantly differed due to irrigation methods (Table 3). Nitrogen scheduling had also non-significant influence on number of internodes per millable cane at harvest during both the years of investigation. It is clearly indicated by results that internode length was significantly influenced by irrigation methods. I_3 (drip irrigation) increased 16.18% internode length as compared to I_1 (flood irrigation) which was significantly higher than I_1 (flood irrigation) and I_2 (furrow irrigation) at harvest in pooled analysis of two years. This might be due to continuous soil moisture availability and better crop stand. Sarala *et al.* (2014) reported similar findings. The results further revealed that N_3 (6 splits) recorded significantly highest length of internodes as compared to N_1 (farmers practice) which was statistically at par with N_4 (8 splits), N_5 (10 splits) and N_2 (4 splits) during both the years of study. This might be due to continuous better supply of nitrogen according to crop need (Kumar *et al.* 2014). Number of millable canes and single cane weight (Table 3) were recorded highest under drip irrigation over flood and furrow irrigation. This was due to availability of water to plants and photosynthetic rate at available soil moisture which leads to increase in number of tillers. This was in agreement with the findings of Prajapati *et al.* (2013). Among nitrogen scheduling, N_3 (6 splits) produced significantly higher number of millable canes and single cane weight as compared to N_1 (farmers practice) being at par with N_4 (8 splits), N_5 (10 splits) and N_2 (4 splits) in pooled analysis of both the years of study. This was due to higher number of tillers which ultimately converted into maximum number of millable cane. Higher accumulation of weight by cane due to nutrient availability suffices the crop demand. This is similar to results from Ramesh *et al.* (1994).

Yield: Analyzed results indicated that irrigation methods posed significant effect on cane stalk yield, cane top, cane trash and biological yield at harvest. I_3 (drip irrigation) exhibited their superiority over I_1 (flood irrigation) and I_2 (furrow irrigation). Increased cane yield in tune of 22.30% was observed under drip irrigation in pooled analysis of two years, over flood irrigation. Similar results also observed in case of cane top, cane trash and biological yield of sugarcane. This might have been due to flourished growth, higher biomass accumulation and favorable yield attributing parameters. Narayanamoorthy (2010) also resulted that the cane yield of sugarcane cultivated under drip method of irrigation is much higher than the under the surface irrigation. These findings are also supported by Singandhupe *et al.* (2008). An examination of data further revealed that nitrogen fertilization scheduling also gave a significant result regarding cane stalk yield, cane top, cane trash and biological yield. Maximum cane yield of sugarcane was recorded with N_3 (6 splits) which was significantly higher than N_1 (farmers practice) but remained at par with N_4 (8 splits), N_5 (10 splits) and N_2 (4 splits) during both the years of experimentation. The cane yield was observed 10.09% higher in 6 split application of nitrogen in pooled analysis of two years, over farmers practice. Similar leaning was also observed in cane top, cane trash and biological yield. This might be due to prosperous growth and increased yield attributing characteristics of crop (Sreewarome *et al.* 2007) and Butler *et al*. (2002). The data with respect to harvest index revealed that nitrogen scheduling failed to have significant influence on it.

Quality: The data (Table 2) exposed that irrigation methods did not exert any significant influence on commercial cane sugar and fiber per cent at harvest in pooled analysis of two years of study. Higher fiber per cent (13.78%) was recorded in I_3 (drip irrigation). This is similar to results from Ramesh *et al.* (1994). A perusal of data regarding commercial cane sugar and fiber per cent indicated that it was not affected significantly due to nitrogen scheduling during both the years of study. Rajanna and Patil (2003) reported that any quality parameter did not differ significantly due to fertigation up to 240 DAP in sugarcane.

It was concluded that irrigation through drip irrigation and nitrogen fertilization in 6 equal splits proved to be better options in respect to phenology, yield attributes and yield potential of sugarcane.

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