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Effect of date and level of earthing and nitrogen on productivity and nutrient availability in soils of ratoon sugarcane (*Saccharum officinarum)*

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ABSTRACT

A field experiment was carried out during the spring seasons of 2008-09 and 2009-10 at Varanasi, Uttar Pradesh to find out the exact time and the height of earthing up and optimum dose of nitrogen for getting higher productivity, monetary returns, and changes in the fertility status of soils for ratoon sugarcane (*Saccharum officinarum* L.) at Varanasi. Earthing up on 25th April up to 20 cm height with 210 kg N/ha gave the highest cane yield, net returns and B:C ratio.

Key words : Earthing up, Nitrogen, Soil fertility, Sugarcane ratoon

Sugarcane is an important commercial cash crop and also unique in the sense that a number of succeeding ratoons are taken from a single planting. In India more than 50 to 55% of sugarcane acreage is occupied by ratoons, which are often poor yielder than the plant cane due to non adoption of improved agricultural technologies. Therefore, even a small improvement in ratoon productivity would add considerably to overall sugarcane production in the country and benefit cane growers by vacating the fields earlier for sowing of wheat and other *rabi* crops timely and mill owner's by providing mature cane in early crushing period. The ratoon crop often gives better quality juice and sugar recovery than plant cane. Excessive tillering in ratoon crop is a desired inheritance character but all tillers may not be millable cane. Earthing up plays an important role in reducing the number of excessive tillers. Besides, it has added advantages of pruning/cutting of old roots, moisture conservation, addition of organic matter, enhanced availability and uptake of plant nutrients, efficient utilization of solar radiation, suppression of weeds and preventing canes from lodging (Yadav and Shukla, 2008). Ratoons are highly exhaustive of nitrogen because of shallow root system, decaying of old roots, sprouting of stubble buds and immobilization of nitrogen (Lal and Singh, 2008). Considering the above, a field experiment was conducted to test different time and level of earthing up along with different levels of nitrogen for higher growth, yield and economics of production of ratoon cane in the Gangetic alluvium of Uttar Pradesh at Varanasi. Changes in soil fertility status also stated.

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MATERIALS AND METHODS

The field experiment was carried out during spring seasons of 2008-09 and 2009-10 at the Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, (U.P.).The experimental soil was a sandy clay loam with pH 7.9, organic carbon 0.33%, available N (185.6 kg/ha), available P (24.4 kg/ha) and available K (235.37 kg/ha). The soil was thus low in available N and medium in available P and K. Eighteen treatments comprised of all 18 combinations of 3 dates (25^{th} April, 25^{th} May and 25^{th} June) and two levels (10 cm and 20 cm in height) of earthing up and three nitrogen levels (viz. 150, 180 and 210 kg N/ha). Six combinations of date and level of earthing up were assigned to main plots, while 3 N levels were the sub-plots. The experiment was laid out in a split–plot design with three replications. The planted cane crop had a row spacing of 90 cm and the same was maintained. The planted crop was harvested and then the field was irrigated. One or two days after irrigation, basal doses of fertilizer 80 kg P_2O_5/ha, 80 kg K_2O/ha and $1/3^{rd}$ of N as per treatment were applied. Rest $2/3^{rd}$ of N in the form urea was top dressed in two equal splits before earthing up in the month of April and May as per treatments. To layout the experiment in already planted sugarcane field, stubbles of each fifth row were uprooted to convert it into an irrigation channel as well as boundary for the experimental plots.

Sugarcane ratoon was harvested after the completion of 12 month i.e., on 15th February/March. Various growth parameters viz. number of tillers/ha, height of tillers, LAI, dry matter accumulation and number of millable canes were recorded in standing crop, while yield and yield attributes like cane length, cane diameter, cane weight and cane yield were noted after the harvest of ratoon crop. Economic analysis was done based on the prevailing market price of the inputs and produce i.e. fertilizer N @ ₹11.30/kg, P @ 21.25/kg, K @ 8.00/kg and cost of sugarcane @ 2,932.50/t (Sugarcane Corporation of India). Green leaves and trashes were analysed to compute uptake of nutrients (N, P and K) by the plants. Soil samples (0-22.5 cm) were collected before the start and harvest of ratoon crop and were composited over replications. Soil samples were analysed for pH, EC, organic C, available N, P and K contents by following standard procedures.

RESULTS AND DISCUSSION

Tillers and millable cane

Results obtained from the ratoon crops of sugarcane showed that earthing up at 25th June produced significantly more tillers than 25th April earthing in both the years of study (Table 1), however, number of millable canes/ha was not significantly influenced by the date of earthing up (Table 1). This was due to the fact that late tillers face considerable competition for soil moisture, nutrients and soil aeration and thus do not develop into millable canes. Singh *et al*. (2008) also reported more tillers with early earthing up. Similarly, 10 cm height of earthing recorded significantly more, but number of millable canes were not affected by the levels of earthing up.

Each successive increase in rate of N application significantly increased the number of tillers at 60 as well as 120 days after ratooning (DAR), but with respect to millable canes/ha 180 and 210 kg N/ha were at par and significantly superior to 150 kg N/ha. Increase in productive tillers due to N application has been reported by Shukla (2005) and Lal *et al*. (2008).

Growth attributes

Early earthing up significantly increased plant height, leaf area index and dry matter/tiller (Table 1). This was due to conducive soil environment associated with early earthing up. Higher LAI and dry matter/tiller was recorded under 20 cm height of earthing up. This was because of higher earthing up provided more soil volume to the roots for proper growth and development resulting in increased plant growth parameters as compared to 10 cm height of earthing up from the ridge. Successive levels of nitrogen significantly increased height of tillers at 120 DAR, increased LAI up to grand growth stage and dry matter/tiller

Table 1. Effect of time, level of earthing up and nitrogen levels on number of tillers/ha, height of tillers (cm), leaf area index and dry matter (g)/tiller of ratoon sugarcane

Treatment	Number of tillers/ha('000/ha) 60 DAR 08-09	60 DAR 09-10	120 DAR 08-09	120 DAR 09-10	Height of tillers (cm) 120 DAR 08-09	120 DAR 09-10	Max. tillering stage 08-09	Max. tillering stage 09-10	Leaf area index Grand growth stage 08-09	Grand growth stage 09-10	Harvest 08-09	Harvest 09-10	Dry matter (g)/tiller Max. Tillering stage 08-09	Max. Tillering stage 09-10	Grand growth stage 08-09	Grand growth stage 09-10	Harvest 08-09	Harvest 09-10
Date of earthing up																		
25th April	205	190	121	89.3	190	153	4.3	3.8	7.2	6.2	6.8	5.1	79.7	65.8	360.1	318.7	467.5	430.0
25th May	247	205	132	102.2	173	147	3.8	3.6	6.6	5.3	6.1	4.3	70.6	57.2	346.0	304.1	370.7	417.6
25th June	263	215	137	118.5	164	139	3.7	3.5	6.4	5.1	5.8	4.0	65.8	52.2	342.9	302.0	326.1	388.2
SEm±	03	06	03	01.9	02	02	0.1	0.1	0.1	0.2	0.2	0.1	1.4	0.7	4.4	4.3	10.2	10.0
CD (P=0.05)	10	19	09	05.9	06	06	0.4	0.2	0.3	0.5	0.5	0.3	4.4	2.3	13.9	13.7	32.2	31.7
Level of earthing up																		
10 cm height	249	212	134	110.3	170	144	3.7	3.5	6.4	5.2	5.8	4.3	70.2	56.1	342.8	301.1	391.3	364.2
20 cm height	229	194	125	96.3	181	149	4.2	3.7	7.1	5.8	6.6	4.6	73.8	60.7	356.1	315.4	432.2	412.0
SEm±	02	05	02	01.5	02	01	0.1	0.1	0.1	0.1	0.1	0.1	1.1	0.6	3.6	3.5	8.3	8.2
CD (P=0.05)	8	16	07	04.8	05	05	0.3	0.2	0.3	0.4	0.4	0.2	3.6	1.9	11.4	11.2	26.3	25.9
Nitrogen levels (kg/ha)																		
150	230	187	121	73.8	142	137	3.5	3.4	5.9	4.8	5.7	3.8	63.1	51.1	340.4	297.2	346.3	328.5
180	240	206	131	108.8	182	148	4.0	3.7	7.0	5.7	6.4	4.6	74.1	60.0	352.7	312.7	440.2	414.8
210	246	216	137	127.4	203	155	4.3	3.8	7.3	6.0	6.6	4.9	78.8	64.2	355.3	314.9	448.7	421.0
SEm±	01	03	0.3	0.6	00.4	00.8	0.1	0.1	0.05	0.1	0.1	0.06	0.5	0.3	3.6	1.6	4.8	3.3
CD (P=0.05)	1.9	10	0.9	1.7	01.3	02.4	0.3	0.2	0.1	0.2	0.3	0.2	1.5	0.8	10.5	4.7	14.1	9.6

at harvest. These values were highest at180 kg N/ha and least at 150 kg N/ha. Ali *et al*. (2002) and Lal and Singh (2008) also reported an increase in LAI with increase in rate of nitrogen application.

Cane length, diameter and weight and cane yield

April earthed up crop recorded significantly higher cane length, cane diameter, cane weight and cane yield as compared to the late earthed up crop in both first and second ratoon. These higher yield and yield attributes were due to the fact that earlier and higher earthed up crop had comparatively longer period of growth, reduced excessive tillers, increased soil volume and thereby increased availability of soil moisture and nutrients for better growth of roots and shoots. Qadir *et al*. (1998) also reported that delaying the earthing up significantly reduced yield attributes resulting in lower yields of cane. In earthing up crop to a height of 20 cm produced higher soil volume also significantly recorded higher cane length, cane diameter of top middle and bottom cane weight as well as cane yield. Similar findings were reported by Dougall and Halpin (2008). Increased cane length, cane diameter, cane weight and cane yields were observed at higher doses of nitrogen levels. Application of nitrogen at 210 kg/ha increased the cane length by 8.57 and 8.88%, weight of cane by 19.24% and 19.60% and cane yield by 22.1 and 25.2% as compared to 180 kg N/ha and 150 kg N/ha, respectively in first and second ratoon crops of sugarcane. There was a significant increase in all the yield attributes with each increment of nitrogen level during both the years of investigation. Similar findings were reported by Choudhary and Ullah (2001).

NPK uptake

The highest, N, P and K uptake was recorded with the earliest earthing up (25th April) (Table 3), which was significantly more than 25th May and 25th June earthing up. This was followed by more uptake with 25th May earthing up. Least NPK uptake was recorded with 25th June earthing up. Higher NPK uptake with earlier earthing up was due to higher cane yield obtained with it. As regards height of earthing up, it was generally higher with 20 cm than with 10 cm. Successive increments of nitrogen applied to ratoon significantly influenced the NPK uptake, the highest uptake was obtained under 210 kg N/ha. These results are in

Table 2. Effect of time, level of earthing up and nitrogen levels on number of millable canes/ha, cane length (cm), cane diameter (cm), cane weight (g) and cane yield (t/ha) of ratoon sugarcane

Treatment	No. of millable cane		Cane length (cm)		Cane diameter(cm)						Cane weight (g)		Cane yield(t/ha)	
					Top of cane		Middle of cane		Bottom of cane					
	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10
Date of earthing up														
25th April	105.1	101.1	383.8	331.0	2.5	2.4	2.6	2.5	2.9	2.5	1502.7	1416.6	173.5	144.1
25th May	111.4	108.0	363.0	303.7	2.4	2.3	2.5	2.3	2.6	2.4	1404.2	1219.4	158.4	132.0
25th June	112.6	109.5	361.1	296.9	2.3	2.2	2.4	2.2	2.6	2.3	1366.0	1138.9	149.7	128.7
SEm±	2.5	3.3	5.3	4.4	0.03	0.03	0.03	0.02	0.06	0.03	17.2	16.8	3.0	1.6
CD (P=0.05)	NS	NS	16.7	13.9	0.1	0.10	0.1	0.07	0.2	0.1	54.2	53.1	9.4	5.2
Level of earthing up														
10 cm height	112.6	108.9	361.6	301.7	2.3	2.2	2.5	2.3	2.6	2.4	1401.9	1200.0	155.4	131.1
20 cm height	106.8	103.7	377.0	319.4	2.4	2.3	2.6	2.4	2.8	2.5	1446.7	1316.6	165.6	138.1
SEm±	2.1	2.7	4.3	3.6	0.03	0.02	0.03	0.02	0.05	0.02	14.0	13.7	2.4	1.3
CD (P=0.05)	NS	NS	13.6	11.4	0.09	0.08	0.08	0.06	0.16	0.1	44.2	43.3	7.7	4.2
Nitrogen levels (kg/ha)														
150	105.3	100.5	348.8	294.2	2.2	2.1	2.3	2.2	2.5	2.3	1258.6	1105.5	137.1	112.6
180	111.4	108.4	377.6	314.5	2.4	2.3	2.6	2.4	2.7	2.4	1455.7	1294.4	168.4	141.6
210	112.6	109.6	381.5	322.9	2.5	2.4	2.7	2.4	2.8	2.5	1558.6	1375.0	176.1	150.6
SEm±	1.0	1.3	4.0	2.3	0.02	0.01	0.01	0.02	0.04	0.03	6.7	6.6	1.4	0.9
CD (P=0.05)	2.9	4.0	11.8	6.9	0.06	0.03	0.04	0.07	0.10	0.1	19.6	19.3	3.9	2.6

Table 3. Effect of time, level of earthing up and nitrogen levels on total nutrient uptake (kg/ha), net available soil nutrient (kg/ha) and loss or benefit over initial values of soils of ratoon sugarcane

Treatment	Total nutrient uptake (kg/ha)						Net available soil nutrient (kg/ha)						Loss (-) or benefit (+) over initial values (kg/ha)					
	N		P		K		N		P		K		N		P		K	
	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10
Date of earthing up																		
25th April	230.3	160.1	26.2	23.3	227.4	160.3	134.0	150.5	77.6	114.5	85.8	20.2	3.2	10.4	19.8	31.8	-14.6	-32.7
25th May	201.5	123.7	23.0	20.3	202.1	123.7	164.1	191.5	81.4	124.7	112.4	59.9	28.9	46.4	16.4	38.3	8.8	3.3
25th June	191.9	111.9	21.9	18.7	191.5	113.2	171.7	214.0	82.6	123.8	123.8	79.6	33.2	56.5	20.0	36.3	11.0	14.5
SEm±	3.4	1.8	0.3	0.2	3.0	2.2	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	10.6	5.6	1.0	0.7	9.3	7.0	-	-	-	-	-	-	-	-	-	-	-	-
Level of earthing up																		
10 cm height	201.6	126.3	22.2	19.5	200.4	126.3	161.2	186.8	81.9	119.7	114.3	56.5	18.8	35.3	17.5	32.4	5.9	-3.6
20 cm height	214.2	137.6	25.2	21.9	213.6	138.4	152.0	183.8	79.1	122.4	100.5	49.9	18.9	40.3	19.8	38.5	-2.3	-6.2
SEm±	2.7	1.5	0.3	0.2	2.4	1.8	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	8.6	4.6	0.8	0.6	7.6	5.7	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg/ha)																		
150	187.1	113.6	20.9	18.4	184.8	113.6	147.1	159.0	81.7	118.2	131.0	63.6	24.4	25.5	25.0	37.2	33.8	9.1
180	214.2	137.4	24.1	21.2	212.4	138.6	152.6	184.2	80.9	122.3	103.0	50.1	9.8	31.6	17.4	35.3	-5.6	-9.7
210	222.4	144.9	26.0	22.6	223.7	144.9	170.1	212.8	78.8	122.4	88.1	46.1	22.3	56.3	13.8	34.0	-22.8	14.2
SEm±	1.2	0.8	0.2	0.2	1.5	1.0	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	3.5	2.3	0.6	0.4	4.3	2.3	-	-	-	-	-	-	-	-	-	-	-	-

conformity with the findings of Ashraf *et al.* (2008).

Residual soil fertility

Different treatments brought about significant changes in the status of available soil N, P and K. Available N, P and K in soil increased as the earthing up was delayed. Similarly, significantly higher N, P and K was present in soil with 10 cm high earthing up than with 20 cm high earthing up. This was in the reverse direction of that recorded for cane yield and N, P and K uptake. Thus the earthing up treatments that recorded higher yield and N, P and K uptake left soils poorer in available N, P and K. C content of the soil increased from the initial soil test value of 0.34 to 0.35%, available N from 184.0 to 186.85 and available P from 23.0 to 81.95 kg/ha. However, available K declined from 233.0 to 114.32 kg/ha showing that sugarcane leads to heavy depletion of soil K.

Nitrogen application increased available N in soil. As regards available P, the effect was conspicuous in the second year of study when N application increased it. Nitrogen application decreased K content in soil. This was due to increased cane yield and K uptake due to N fertilization. These results suggest adequate K fertilization of sugarcane in the Gangetic alluvium.

Economics

Maximum net monetary returns and B:C ratio were obtained with 25th April earthing up crops as compared to 25th May and 25th June (Table 4). However, net returns and B:C ratios for 25th May and 25th June earthing up did not differ much. Higher net return and B: C ratios were also obtained with 20 cm height of earthing up as compared to 10 cm earthing up. Nitrogen application increased net return and B:C ratio, and the highest values were obtained with the highest rate of nitrogen application i.e. 210 kg N/ha.

It is concluded that both first and second ratoon crops raised from a single plant cane proved beneficial for farmers when earlier 20 cm high earthing was done on 25th April and 210 kg N/ha was applied.

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Table 4. Effect of time, level of earthing up and nitrogen levels on gross return, total cost of cultivation, net return and benefit : Cost ratio of ratoon sugarcane

Treatment	Gross return (₹/ha)		Cost of cultivation (₹/ha)		Net return (₹/ha)		Benefit: Cost ratio	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Date of earthing up								
M_1 - 25th April	5,08,789	4,22,769	80,265	93,455	4,28,524	3,29,313	6.3	4.5
M_2 - 25th May	4,64,475	3,87,253	80,265	93,455	3,84,210	2,93,797	5.7	4.1
M_3 - 25th June	4,39,060	3,77,478	80,265	93,455	3,58,795	2,84,022	5.4	4.0
Level of earthing up								
L_1 - Light (10 cm height)	4,55,841	3,84,375	79,745	92,935	3,76,096	2,91,439	5.7	4.1
L_2 - Heavy (20 cm height)	4,85,709	4,07,292	80,785	93,975	4,04,924	3,13,316	6.0	4.3
Nitrogen levels (kg/ha)								
N_1 - 150	4,02,078	3,30,395	79,926	93,116	3,22,152	2,37,279	5.0	3.5
N_2 - 180	4,93,800	4,15,438	80,265	93,455	4,13,535	3,21,982	6.1	4.4
N_3 - 210	5,16,446	4,41,667	80,604	93,794	4,35,842	3,47,873	6.4	4.7

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