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Yield and quality analysis of spring–planted sugarcane as influenced by nutrient and weed management

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ABSTRACT

A field study was conducted during spring season in 2007-08 and 2008-09 at Muzaffarnagar to evaluate the influence of nutrient and weed management practices on yield attributes, yield, quality, nutrient uptake and economics of sugarcane. Results showed that application of 125% of recommended dose of fertilizer (RDF) enhanced the cane yield to the tune of 15.52 and 3.60% over 75 and 100% RDF owing to remarkable improvement in cane length, cane girth, cane weight and NMC. Sucrose, available sugar and commercial cane sugar (CCS) yield were also improved by 17.3, 23.4 and 42.6% over 75% RDF while 2.73, 3.15 and 6.84% over 100% RDF, respectively under application of 25% higher RDF. The values of juice extraction and purity per cent were remained statistically unchanged under 100 and 125% RDF but significantly improved over 75% RDF. The uptake of NPK in cane, green tops, trash as well as in total produce along with net return and B:C ratio were also noticed higher under fertility enrichment with 125% in comparison to lower ones. Weed free treatment produced maximum values of cane and CCS yield, yield components, juice extraction and nutrient uptake which was followed by application of glyphosate 1.0 kg/ha at 25 days after planting followed by one hand weeding at 60 DAP and performing of three hand weeding at intervals of 30, 60 and 90 days after planting (DAP). Although, the higher B:C ratio was registered under application of glyphosate 1.0 kg/ha, at 25 DAP followed by one hand weeding at 60 DAP owing to lower cost of cultivation. Consequently, application of 125% recommended dose of N: P_2O_5:K_2O along with glyphosate applied 1.0 kg/ha at 25 DAP followed by one hand weeding at 60 DAP proved valuable in enhancing the yield, quality and economics of spring planted sugarcane.

Key words: Nutrient levels, Quality, Sugarcane, Weed management, Yield

Sugarcane (*Saccharum officinarum* L.) is grown extensively in tropical and sub- tropical regions of India as cash crop and plays a pivotal role in both agricultural and industrial economy of the country. In India, sugarcane is grown under different agro-climatic conditions and occupies about 2.54% (5.08 mha) of gross cropped area with an average productivity of 68.4 t/ha. Sugarcane production coupled with improved quality traits needs sufficient amount of plant nutrients in the soil. Imbalanced and inadequate use of plant nutrients results in poor cane yield and emergence of multiple nutrient deficiencies.

Nitrogen, phosphorus and potassium account for bulk of essential nutrients, which many soils are deficient and need supplementation through organic and inorganic sources. Higher fertilizer doses proved to be superior in respect to growth and yield. Thus, to make the sugarcane cultivation more remunerative, there is need to refine NPK recommendation upto the desired level. Due to slow germination and initial growth, wide row spacing, slow lateral spread, adequate supply of nutrients and moisture, long duration and diversity in weed population, sugarcane generally suffers from the tremendous weed problems. Uncontrolled weeds may cause 12 - 72% cane yield reduction. It is well established fact that a mechanical method of weed management is most effective to control weeds. However, higher cost involvement and lack of labour availability in proper time make it difficult to adopt by the farmers. On the other hand, only application of herbicide is not proved so effective method. Similarly, alternative herbicides should be tested to minimize the chances of weed resurgence against commonly used herbicides having same mode of action. Therefore, there is need to develop the most effective and economical fertilizer management and weed control practices for obtaining maximum yield as well as profitability. Keeping in view, a field experiment was conducted to recommend the best suitable fertilizer management and weed management technique for spring planted sugarcane crop.

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MATERIALS AND METHODS

An investigation was carried out during spring seasons of 2007-08 and 2008-09 at Agricultural Research farm of Chaudhary Chhotu Ram (P.G.) College, Muzaffarnagar (Uttar Pradesh) geographically situated at 28.0^0 N latitude and 77.0^0 E longitude at an altitude of 245.82 meters above the mean sea level. The soil of the experimental field was sandy- loam of Indo-Gangetic alluvial origin, very deep (>2m), well drained, flat and classified as non-calcareous mixed hyperthermic *Udic Ustochrept*, having pH 7.5 and was low in organic carbon (0.48%), medium in both available phosphorus (14.24 kg/ha), potassium (203.92 kg/ha) and low in available nitrogen (155.45 kg/ha) contents.

The experiment was laid out in a factorial randomized block design. The treatments consisted of total 21 combinations of three levels of NPK and seven weed control measures with three replications. The NPK levels were the application of 75% N: P_2O_5: K_2O (F_1), 100% (150 :60 : 60 kg/ha) N: P_2O_5: K_2O (F_2) and 125% N: P_2O_5: K_2O (F_3) of the recommended dose of fertilizer (RDF). Under weed control measures, the treatments were: three hand weedings at 30, 60 and 90 DAP (W_1), one hand weeding at 30 DAP followed by post emergence spray of atrazine 2.0 kg/ha (W_2) , atrazine 2.0 kg/ha as pre-emergence + 2, 4-D 1.0 kg/ha at 60 DAP (W_3), glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) and *Sesbania sesbane* L. (Dhaincha) sowing in inter space followed by 2,4-D spray 1.0 kg/ha at 45 DAP (W_5), weedy check (W_7), weed free (W_6).

Urea, diammonium phosphate and muriate of potash were taken as fertilizer sources for N, P and K, respectively. The amount of fertilizers and herbicides were calculated on the basis of gross plot area. Full dose of P and K and half dose of N were applied as basal. Remaining half N was top dressed in two equal splits after first irrigation and at the time of earthing up. All the herbicides were applied with the help of manually operated knapsack sprayer fitted with flat fan nozzle using a volume spray of 600 litres water/ha.

A mid-late variety of sugarcane *'CoS-97264'* was planted on 23rd and 24th March of 2007 and 2008, respectively on leveled soil by opening 15 cm deep furrow at 75 cm row spacing. During 2008-09, the experiment was conducted in the adjacent to the experimental plot of 2007-08. All the recommended agronomic practices were followed throughout the cropping period. The crop was harvested on 20th and 21st February 2008 and 2009, respectively.

Whole cane samples were taken at the time of harvest and analyzed for quality parameters through standard laboratory procedures. The economics of experiment was worked out on the basis of cost of cultivation and cane yield at prevailing market prices of the treatments. The uptake of N, P and K by sugarcane plant was calculated by multiplying the concentration with their respective dry matter yield (kg/ha). The per cent available sugar was calculated as; available sugar (%) = {S – (B – S) x 0.4 x 0.73}, where S and B are sucrose and brix per cent in cane juice, respectively. The trend of results was similar during both the years hence, data were subjected to pooled analysis for results and discussion.

RESULTS AND DISCUSSION

Yield attributes

NPK levels had significant impact on yield attributes (Table 1). Among the different fertility levels of NPK, the application of 125% (F_3) of the recommended dose of NPK was superior to all other fertility levels in terms of cane length, cane girth, number of internodes/cane, single cane weight as well as number of millable canes (NMC). It was followed by NPK application at 100% (F_2) recommended dose except in case of cane girth where both the treatments yielded statistically similar response. The lowest yield attributes of sugarcane was obtained from the plots receiving 75% (F_1) recommended dose of NPK.

The increase in yield components under higher dose of fertility might be ascribed to better nutritional environment for plant growth at active vegetative stages as a result of improvement in root growth, cell multiplication and elongation in the plant body, which ultimately increased the cane length. The maximum cane girth, number of internodes/cane, individual cane weight and number of millable canes with highest level of NPK was primarily due to the improved fertility status of soil which created congenial environment for better growth and development of sugarcane plant. The positive response with NPK on yield attributes of sugarcane was also reported by Shukla (2007).

Weed management modules under investigation also significantly influenced the yield components of sugarcane (Table 1). Weed free plots (W_6) produced maximum values of yield attributes, *viz.* cane length, cane girth, single cane weight, number of internodes/ plant and NMC being at par with application of glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) and performing of three hand weeding at 30, 60 and 90 DAP (W_1). The latter two treatments (W_1 and W_4) were also tended the similar response except in generation of NMC where W_4 showed

superiority over W_3 The lowest values of yield parameters were observed under control *i.e.* weedy check (W_7) treatment.

Sugarcane raised with weed free (W_6), application of glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) and three hand weeding at 30, 60 and 90 DAP (W_1) produced highest yield components by virtue of reduced competition of weeds for nutrient, moisture and sunlight. These results are in agreement with the findings of Srivastava and Chauhan (2006).

Yield

Fertility levels brought significant variations among cane, green tops and trash yields (Table 1). Significantly higher commercial cane sugar (CCS) and cane, green tops as well as trash yields were obtained with 125% (F_3) recommended dose of NPK. However, fertilization of cane crop with being 100% RDF produced equal green top and trash yields as obtained with 125% recommended dose of NPK as compared to 75% (F_1) recommended dose of NPK. The increase in yield under higher doses of fertilizer might be due to enhanced cane growth and development attributed to the production of lengthiest, thickest and heaviest canes. The increased rate of cane growth coupled with better expression of yield components might have attributed for enhancing the cane yield under higher fertility. Saini *et.al.* (2007) and Naidu *et.al.* (2008) reported increase in cane yield with corresponding increase in levels of fertilizer.

The highest cane, green tops and trash yields were obtained under weed free conditions (W_6) which was found on par with the application of glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4). It was followed by adoption of weed management schedule W_1, in which three hand hoeing were performed at interval of 30, 60 and 90 DAP. While the lowest values of yields of cane, green tops and trash were noticed by un-weeded plots (W_7).

The increase in cane, green tops and trash yields with these treatments was because of the fact that the weed population and weed growth remained low under their initial crop growth period as compared to weedy check. The reduced crop-weed competition provided proper development of growth characters which enhanced the yield attributes, *viz*. cane length, cane diameter , number of internodes/cane, cane weight and NMC/ha which led to higher cane, green top and trash yield. A negative correlation between most of the growth, yield attributes and dry matter of weeds at final harvest has also been established by the earlier researchers. This finding was in conformity with Singh and Menhi (2008).

Table 1. Effect of fertilizer and weed management on yield components and yield of spring–planted sugarcane (pooled data of two cycles)

Treatment	Cane length (cm)	Cane girth (cm)	Number of internodes/ cane	Single cane weight (g)	NMC* (x10^3₹/ha)	Yield (t/ha)		
						Cane	Green tops	Trash
Fertilizer levels								
F_1	247.7	6.35	20.30	709.2	90.0	76.20	15.29	7.94
F_2	265.2	7.00	23.33	798.7	108.0	84.97	17.40	8.79
F_3	277.4	6.96	23.82	818.4	110.1	88.03	17.64	9.03
LSD (P=0.05)	4.8	0.17	0.24	12.1	2.3	3.24	0.66	0.37
Weed control								
W_1	269.8	7.03	23.25	802.8	112.1	89.55	17.99	9.24
W_2	262.5	6.65	22.20	778.6	103.6	84.18	16.68	8.51
W_3	253.7	6.50	21.75	757.7	88.8	78.61	16.38	7.97
W_4	276.1	7.15	23.46	818.7	117.4	90.08	18.45	9.32
W_5	257.2	6.33	22.62	780.7	93.1	81.41	16.73	8.31
W_6	283.4	7.24	23.88	826.3	127.4	97.50	18.93	9.67
W_7	241.3	5.85	20.25	663.1	76.4	60.13	12.25	7.10
LSD(P=0.05)	13.9	0.25	1.02	40.7	5.2	4.65	0.85	0.44

#Details of treatments are given in Materials and Methods; *Number of millable canes

Juice quality

Fertility levels caused significant impact on juice quality parameters except brix percentage which nullify the effect of fertility levels (Table 2). The juice quality and CCS yield were improved with each successive increase in NPK levels. The crop fertilized with NPK at 125% (F_1) of recommended dose significantly boost the sucrose and available sugar % and CCS yield but was reported on par in terms of juice extraction % and purity % with the application of 100% RDF. The lower values of these parameters were recorded under lowest fertility treatments. The remarkable improvement in CCS under high fertility conditions in comparison to sub fertility conditions was due to production of higher cane yield coupled with enhanced juice quality parameters.

The probable cause of improvement in juice quality parameters on account of 125% of RDF might be that N, P and K are the integral part of various sucrose metabolizing enzymes which are involved in sucrose synthesis and its accumulation in sugarcane. The improvement

Table 2. Effect of fertilizer and weed management on juice quality and commercial cane sugar (CCS) yield of spring–planted sugarcane (pooled data of two cycles)

Treatment	Juice extraction (%)	Brix (%)	Sucrose (%)	Purity coefficient (%)	Available sugar (%)	CCS yield (t/ha)
Fertilizer levels						
F_1	48.00	18.71	13.43	72.43	11.94	9.09
F_2	51.61	18.95	15.33	80.89	14.28	12.13
F_3	52.32	19.10	15.75	81.73	14.73	12.96
LSD (P=0.05)	1.11	NS	0.36	1.84	0.18	0.33
Weed control						
W_1	51.63	19.08	15.15	79.40	14.01	12.54
W_2	50.41	18.85	14.61	77.50	13.38	11.26
W_3	49.15	18.82	14.43	76.67	13.15	10.33
W_4	52.48	18.90	15.08	79.78	13.97	12.58
W_5	50.05	18.63	14.76	79.22	13.63	11.09
W_6	53.00	19.36	15.18	78.40	13.96	13.61
W_7	47.75	18.80	14.63	77.81	13.42	8.06
LSD(P=0.05)	2.56	NS	NS	NS	NS	0.53

#Details of treatments are given in Materials and Methods

Table 3. Effect of fertilizer and weed management on nutrient uptake (kg/ha) of sugarcane (pooled data of two cycles)

Treatment	N uptake (kg/ha)				P uptake (kg/ha)				K uptake (kg/ha)			
	Cane	Green tops	Trash	Total	Cane	Green tops	Trash	Total	Cane	Green tops	Trash	Total
Fertilizer levels												
F_1	79.10	35.94	16.19	131.23	23.71	7.33	4.17	35.21	142.24	72.92	24.05	239.19
F_2	105.71	52.15	23.86	181.72	30.05	9.45	5.34	44.84	166.01	78.71	27.99	273.72
F_3	110.10	53.76	24.24	188.10	31.02	9.91	5.52	46.45	166.9	80.20	28.89	275.99
LSD (P=0.05)	2.05	1.15	0.38	3.43	0.59	0.30	0.12	1.38	5.36	3.35	0.40	8.52
Weed control												
W_1	106.21	52.21	23.90	182.32	30.37	9.64	5.41	45.42	163.90	84.91	28.95	277.75
W_2	94.93	47.76	20.95	163.64	27.88	8.94	4.76	41.58	156.24	77.61	27.99	261.83
W_3	86.64	41.96	18.53	147.13	23.70	7.70	4.25	35.65	144.48	72.90	24.59	176.39
W_4	111.70	55.30	24.99	191.99	32.22	10.47	6.25	48.94	168.85	85.91	30.04	207.48
W_5	97.17	45.04	20.76	162.97	26.58	8.18	4.94	39.70	154.01	74.90	25.01	253.92
W_6	120.22	57.98	25.95	204.15	35.61	11.32	6.52	53.44	182.00	87.93	31.09	301.02
W_7	71.22	30.78	14.91	116.91	21.50	6.04	2.94	30.43	129.39	60.50	21.05	210.94
LSD(P=0.05)	4.91	2.62	1.20	8.35	1.54	0.45	0.28	2.11	6.30	4.21	0.73	11.90

in purity percent might have been attributed to higher phosphorus content in cane that help in better flocculation of non-sugar colloids during purification process and results in minimum turbidity of clarified juice. The beneficial effect of NPK fertilization on the juice quality has also been reported by Singh *et al.* (2008).

Weed management options did not result in significant variations with respect to brix, sucrose, purity and available sugar % except juice extraction and CCS yield (Table 2). Nevertheless, performing three hoeing at intervals of 30, 60 and 90 DAP (W_1) numerically improved the sucrose, purity and available sugar % values.

The highest juice extraction% and CCS yield were recorded from the weed free plots (W_6) which were found at par with glyphosphate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) and followed by adoption of three hoeing at intervals of 30, 60 and 90 DAP (W_1) in case of juice extraction, while no perceivable difference was observed in generation of CCS yield under the treatments application of glyphosphate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) and three hoeing did at intervals of 30, 60 and 90 DAP (W_1). The lowest values of juice recovery and CCS yield (t/ha) was registered under control plots (W_7).

Available sugar is dependent on brix %, sucrose % and purity% of cane juice, which showed non-significant variation under different weed management practices. Non-significant variations in brix, sucrose, reducing sugar and available sugar has also been reported by Singh and Menhi (2008). The highest CCS yield obtained with weed free situations was owing to maximum cane yield and juice recovery % along with numerically improved values of juice quality parameters.

Nutrient uptake

NPK uptake by cane, green top, trash and total uptake differed significantly with varying fertility levels (Table 3). The maximum uptake of NPK in cane as well as in green tops, trash and total was recorded at 125% RDF followed by 100% RDF. The lowest NPK uptake by different sugarcane plant parts (cane, green tops, trash and total) was found under 75% RDF of NPK. The uptake of NPK under 125% RDF was increased to the tune of 43.34, 31.92 and 35.67, respectively over 75% RDF. The higher values of NPK uptake by sugarcane plant parts, *viz*. cane, green top and trash under increased fertility levels was mainly due to increased concentration of these nutrients in root zone followed by better expression of growth and yield attributes. Venkatakrishnan and Ravichandran (2007) also corroborated the similar findings.

All the weed control treatments significantly increased the NPK status in various plant parts of sugarcane over weedy check (Table 3). The highest uptake of NPK was noticed in crop with weed free plots (W_6) which was followed by glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP and three hand weeding carried out at 30, 60 and 90 DAP (W_1). The per cent increase in NPK uptake under weed free (W_6) treatment was to the tune of 74.62, 75.62 and 45.37, respectively over weedy check.

The maximum uptake of NPK by different sugarcane plant parts under weed free, glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP and three hand weeding at 30, 60 and 90 DAP were due to the suppression of weed growth which might have been the deriving force behind higher dry matter accumulation and nutrient uptake in sugarcane under these treatments. A similar result was also reported by Singh *et al*.

Economics

The highest gross and net return and B:C ratio were recorded when the crop was fertilized with 125% RDF and these values recorded lowest in the crop grown under 75% RDF (Table 4) . The second best treatment was 100% RDF, which fetched a gross return of Rs 11,8212/ha, net return of Rs 82,786/ha with B: C ratio of 2.33. The superiority of 125% RDF over other fertility levels in terms of gross, net returns and B : C ratio was primarily due to production of highest cane yield.

The maximum gross and net returns were recorded under weed free plots (W_6) followed by application of glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4), whereas the lowest values of gross, net re-

Table 4. Economic analysis of spring–planted sugarcane as influenced by fertilizer and weed management (pooled data of two cycles)

Treatment	Cost of cultivation (x10^3 ₹/ha)	Gross returns (x10^3 ₹/ha)	Net returns (x10^3 ₹/ha)	B : C ratio
Fertilizer levels				
F_1	34.05	106.89	72.85	2.14
F_2	35.43	118.21	82.79	2.33
F_3	36.64	123.38	86.74	2.36
Weed control				
W_1	37.12	125.52	88.40	2.38
W_2	35.19	117.73	82.54	2.34
W_3	33.78	110.56	76.78	2.27
W_4	35.07	126.54	91.47	2.61
W_5	35.65	114.35	78.71	2.21
W_6	39.00	135.98	96.98	2.48
W_7	31.77	84.96	53.08	1.67

turns and B : C ratio were observed under weedy check plots (W_7). While the higher B :C ratio was noticed under the glyphosphate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP (W_4) treatment over weed-free treatment (W_6) was registered owing to lower cost of cultivation. The lowest of gross, net returns and B : C ratio under the weedy check treatment was due to production of lowered cane yield.

From the present study, it can be ascertained that application of 125% RDF (187.5: 75: 75, $N:P_2O_5:K_2O$ kg/ha) along with post-emergence spray of glyphosate 1.0 kg/ha at 25 DAP + one hand weeding at 60 DAP were the best options for realizing higher productivity, juice quality, net returns and B :C ratio of spring planted sugarcane in Indo-Gangetic plains of Uttar Pradesh.

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