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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND NUTRIENT CONCENTRATION OF SUGARCANE PLANT-RATOON CROP SEQUENCE

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ABSTRACT

An experiment was conducted during spring seasons of 2002-05 at research farm of G.B. Pant University of Agriculture and Technology, Pantnagar to find out the effect of integrated nutrient management on growth, yield and nutrient content of sugarcane-ratoon cropping system. Results revealed that %germination in plant crop and clump population at 45 days after ratooning did not differ significantly under different treatments, T_{10}, however, exhibited highest clump population (16.38 thousand/ha) in ratoon. In plant crop, T_{10} exhibited significantly higher shoot height (371.9 cm) being at par with that of T_5. In ratoon crop, T_{10} resulted in significantly higher shoot height (334.9 cm), being at par with T_5. Plant crop fertilized with T_{10} produced significantly higher dry matter (296.0 g); being at par with T_5 at 240 days after planting. In ratoon crop, at 240 days after ratooning, T_{10} gave dry matter production (328.4 g); being significantly higher than that of T_7. T_{10} resulted in significantly higher number of internodes/cane (22.7 and 24.4) in plant and ratoon crop, respectively. In plant crop, highest biological yield (107.1 t/ha) was obtained under T_{10} being 22.1 and 25.2 % higher than that of T_9 and T_1, respectively. In ratoon crop, T_{10} registered highest biological yield (109.1 t/ha), being 33.2 and 19.8 % higher than that of T_7 and T_9, respectively. In plant crop, T_{10} produced higher dry matter (43.44 t/ha) accounting 28.70, 5.79 and 8.95 t/ha from cane, green tops and trash, respectively. In ratoon crop, T_{10} produced highest dry matter (40.05 t/ha) accounting 25.82, 5.95 and 8.28 t/ha from cane, green tops and trash, respectively.

Key words : *Growth, INM, Nutrient content, ratoon, sugarcane, yield.*

Sugarcane is a major cash crop of India supporting second largest industry next to textile. Sugarcane productivity is low due to increased cost and reduction in factor productivity of inputs such as fertilizers/manures and plant protection measures. Excessive use of high analysis chemical fertilizers can drastically impair soil fertility leading to poor soil health and nutrient deficiencies (Singh *et al*., 2007). Situation warrants for adoption of organic based resources that supply nutrients to plant and in process enrich soil organic carbon. Maintenance of adequate soil organic carbon is of paramount significance. Several workers indicated that substitution of inorganic N through FYM in sugarcane plant significantly increased cane yield of ratoon (Gangwar *et al*., 2003). Singh and Singh (2002) indicated that integration of FYM and sulphitation pressmud cake with N fertilizer improved cane yield of plant crop with residual effect on ratoon cane apart from rejuvenation of soil health.

In recent times, sustainability of land and crop is in alarming situation, integrated use of organics and inorganic fertilizers need to use nutrients and energy more efficiently than conventional systems (Mader *et al*., 2002). In order to meet nutrient requirement of sugarcane-ratoon system, integrated nutrient supply from inorganic fertilizers, organic sources and bio sources seem to be need of time. Keeping issues in view, present investigation was carried out to assess impact of integrated nutrient supply on growth, yield and nutrient content of sugarcane-ratoon cropping sequence.

MATERIALS AND METHODS

A field experiment was executed during spring seasons of 2002-05 at research centre of G.B. Pant University of Agriculture and Technology, Pantnagar to assess impact of INM on growth, yield and nutrient concentration of sugarcane-ratoon crop sequence. The experimental plot was silty clay loam in texture, neutral pH, medium in organic carbon, P_2O_5 and K_2O with low in N. Treatments consisted of ten treatments of nutrients either organic or inorganic or combined as depicted in tables imposing in plant and ratoon crop separately laid out in randomized block design replicated four times. Other farm related operations were carried out as per crop need. Observations were

recorded on growth parameters i.e. germination%, shoot height, number of green leaves/plant, leaf area/shoot, dry matter accumulation/shoot, number of internodes/cane, dry matter yield in cane, green tops, trash and biological yield in both plant and ratoon crops. Further nutrient content i.e. nitrogen, phosphorus and potassium in plant and ratoon crop, respectively were analyzed as per standard procedures.

RESULTS AND DISCUSSION

Effect of INM on growth parameters in sugarcane plant and ratoon crops

Germination% and clump population : Variation in germination at 30 days after planting due to different treatments was not significant. T_{10} gave the highest germination (43.8 %) at 30 days after planting. However, T_1 exhibited minimum germination (32.8 %). Several workers (Navale *et al*., 1995 and Shinde *et al*., 2002) did not observe significant variations in germination owing to integrated nutrient supply. Number of clumps in ratoon crop varied from 14.16 under T_7 to 16.38 thousand ha^{-1} under T_{10}, though the differences among treatments were non-significant at 45 days after ratooning.

Shoot height : Shoot height increased with advancement in crop age, being maximum at 240 days after planting. At this stage, T_{10} exhibited higher shoot height (371.9 cm); being at par with T_5 or T_6 but significantly higher than other treatments. At this stage, T_7 produced lowest shoot height (304.8 cm), however, differences among T_7, T_8 and T_9 were not significant and at par with T_1. At 180 days after ratooning, T_{10} exhibited significantly higher shoot height (334.9 cm) than rest of the treatments and was at par with T_5, T_6, T_2 and T_3. Lowest shoot height (300.6 cm) was noted with T_7. Better growth under integrated nutrient supply was reflected in terms of more shoot height under T_{10} at grand growth phase. Maximum shoot height in plant and ratoon crops was recorded under T_{10} which was 42.3, 67.1 and 51.0 cm more than that of T_1, T_7 and T_8 in plant crop and 19.1, 34.3 and 22.9 cm more than that of T_1, T_7 and T_4 in ratoon crop, respectively. These are in conformity with findings of Jayabal and Chockalingam (1990) and Tamilselvan and Jaybal (1993)

Number of green leaves : At 150 days after planting, T_{10} significantly attained maximum number of green leaves (13.4) as compared to other treatments. Differences between T_6 and T_3 were significant at this stage, however, T_7 registered minimum value (9.9), being at par with T_9, followed by T_8. At 150 days of ratooning, T_{10} exhibited significantly higher number of green leaves (12.5) than that of other treatments. However, differences between T_1 and T_4 and T_5 and T_6 were not significant. T_7 resulted in lowest number of green leaves (10.2); being at par with T_8.

Leaf area per shoot : At 210 days after planting, T_{10} gave highest leaf area per shoot (3553 cm^2) as compared to rest of the treatments. T_1 gave significantly higher leaf area per shoot (3237 cm^2) as compared to T_3. However, T_7 recorded lowest leaf area per shoot (2980 cm^2). Whereas, differences in leaf area per shoot between T_8 and T_9 were significant. T_5 or T_6 produced more leaf area per shoot than T_2 or T_3. At 210 days after ratooning, maximum leaf area (3319 cm^2) was noted from T_{10}; being significantly superior to other treatments. T_7 recorded minimum leaf area (2737 cm^2). T_4 gave higher leaf area per shoot (2947 cm^2) than that of T_9. T_2 exhibited higher leaf area (3069 cm^2) as compared to T_1.

Dry matter accumulation per shoot : At 240 days after planting, T_{10} produced significantly higher dry matter accumulation per shoot (296.0 g), being at par with T_5 or T_6. However, differences in dry matter accumulation per shoot between T_2 or T_3 and T_1 were not significant at this stage. T_1 produced higher dry matter than that of T_2 or T_3 at this stage, whereas, lowest dry matter (245.0 g) was recorded with T_7 being at par with T_8 or T_9. Total dry matter, an integral part of crop growth rate over the growing period is related to economic yield reflecting harvest index (Yoshida, 1972). At 240 days after ratooning, T_{10} gave significantly higher dry matter per shoot (328.4 g) while lowest dry matter (302.2 g) was obtained with T_7. Lower dry matter under T_7 and T_8 may be due to 50% NPK in inorganic fertilizers. Dry matter is function of leaf area index and number and duration of leaves and efficiency of leaf to convert radiant energy to chemical energy. Higher dry matter under T_{10} over rest of the treatments including control may be due to more leaf area per shoot.

Number of internodes per cane : T_{10} exhibited significantly higher number of internodes per cane (22.7); being at par with T_5 or T_6 but higher than that of rest of the treatments. Differences between T_1 and T_2 or T_3 were not significant. T_9, however, produced minimum value (20.1). The differences between T_7 and T_8 were also not significant. T_{10} attained significantly higher number of internodes per cane (24.4); being at par with T_5 and T_6 but was superior to rest of the

Table-1 : Effect of different integrated nutrient management treatments on growth parameters of sugarcane plant and ratoon crop.

Treatments			Germination (%)	Clump population (000/ha	Shoot height (cm)		Number of green leaves		Leaf area/shoot (cm^2)		Dry matter/shoot (g)		Number of internodes/cane	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
T_1	100% NPK	100% NPK	32.8	15.13	329.6	315.8	12.5	11.4	3237	3013	273.5	312.8	21.8	21.9
T_2	75% NPK+25% N (FYM)	100% NPK + trash	36.4	15.55	344.2	320.9	12.4	11.2	3155	3069	270.5	316.4	21.6	23.1
T_3	75% NPK+25% N (CSPM)	100% NPK + trash	37.0	15.83	349.2	322.9	12.1	11.4	3185	3045	267.8	319.6	21.4	23.5
T_4	100% NPK	75% NPK + GM	33.0	15.00	335.4	312.0	12.8	10.9	3255	2947	275.2	307.0	22.0	22.6
T_5	75% NPK+25% N (FYM)+ BF	100% NPK + trash + BF	39.6	16.11	362.7	325.1	12.8	11.6	3340	3274	284.6	320.5	22.4	23.7
T_6	75% NPK+25% N (CSPM)+ BF	100% NPK + trash+ BF	40.5	16.25	366.9	330.3	13.0	11.9	3375	3260	280.0	322.6	22.2	23.9
T_7	50% NPK+25% N (FYM)+ BF	50% NPK + GM+ BF	35.9	14.16	304.8	300.6	9.9	10.2	2980	2737	245.0	302.2	20.9	21.2
T_8	50% NPK+25% N (CSPM)+ BF	50% NPK + GM + BF	36.3	14.44	320.9	305.8	11.8	10.4	3086	2769	265.1	307.5	20.6	21.6
T_9	50% NPK+25% N (VC)+ BF	75% NPK + 25% N (VC) + BF	35.5	15.14	315.3	317.3	10.6	11.1	3021	2910	254.7	310.1	20.1	22.4
T_{10}	100%NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	43.8	16.38	371.9	334.9	13.4	12.5	3553	3319	296.0	328.4	22.7	24.4
SEm±			2.9	0.69	8.5	6.4	0.20	0.18	8.3	7.2	9.0	6.8	0.33	0.26
CD (P=0.05)			NS	NS	24.9	18.6	0.60	0.55	24.3	21.0	26.1	NS	0.9	0.75

Table-2 : Effect of integrated nutrient management on dry matter yield, biological yield and nitrogen content of sugarcane plant and ratoon crop.

Treatments			Dry matter yield (t/ha)						Biological yield (t/ha)		Nitrogen content (%)					
	Plant	Ratoon	Plant			Ratoon			Plant	Ratoon	Plant			Ratoon		
			Cane	Green Tops	Trash	Cane	Green Tops	Trash			Cane	Green Tops	Trash	Cane	Green Tops	Trash
T_1	100% NPK	100% NPK	26.71	4.64	7.71	23.76	4.92	6.91	85.5	93.3	0.502	0.866	0.519	0.498	0.712	0.506
T_2	75% NPK+25% N (FYM)	100% NPK+ trash	26.40	4.59	6.69	24.56	5.27	7.49	96.8	94.8	0.485	0.792	0.496	0.524	0.801	0.539
T_3	75% NPK+25% N (CSPM)	100% NPK+ trash	26.27	4.55	6.63	24.84	5.12	7.63	94.6	98.7	0.478	0.769	0.487	0.522	0.784	0.526
T_4	100% NPK	75% NPK+ GM	26.79	4.67	7.76	22.99	4.63	5.92	86.0	89.6	0.507	0.881	0.516	0.494	0.689	0.496
T_5	75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	27.85	5.72	8.90	25.08	5.86	8.17	103.3	102.9	0.530	0.918	0.540	0.540	0.838	0.550
T_6	75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	27.66	5.69	8.81	25.24	5.78	7.96	101.0	101.5	0.514	0.906	0.529	0.527	0.826	0.549
T_7	50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	25.42	3.52	6.53	22.50	4.49	6.30	90.9	81.9	0.460	0.750	0.483	0.455	0.653	0.477
T_8	50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	24.07	3.40	5.40	22.64	4.27	5.87	90.8	82.9	0.435	0.733	0.457	0.420	0.625	0.439
T_9	50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	25.16	3.49	5.45	23.27	4.69	6.54	87.7	91.0	0.402	0.705	0.429	0.490	0.670	0.493
T_{10}	100%NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	28.70	5.79	8.95	25.82	5.95	8.28	107.1	109.1	0.550	0.935	0.542	0.570	0.856	0.585
SEm±			0.75	0.09	0.08	0.76	0.094	0.26	3.2	2.7	0.006	0.008	0.011	0.008	0.01	0.006
CD (P=0.05)			2.1	0.27	0.24	2.2	0.27	0.77	9.3	8.0	0.017	0.025	0.032	0.024	0.029	0.018

BF-Biofertilizer, VC-vermicompost, GM-Green manuring, CSPM-Carboneous sulphitation pressmud, FYM-Farm yard Manure

Table-3 : Effect of integrated nutrient management on phosphorus and potassium content of sugarcane plant and ratoon crop.

	Treatments		Phosphorus content (%)						Potassium content (%)					
			Plant			Ratoon			Plant			Ratoon		
	Plant	Ratoon	Cane	Green Tops	Trash	Cane	Green Tops	Trash	Cane	Green Tops	Trash	Cane	Green Tops	Trash
T_1	100% NPK	100% NPK	0.0618	0.0761	0.0721	0.0640	0.0794	0.0754	0.736	1.009	0.620	0.740	1.060	0.676
T_2	75% NPK+25% N (FYM)	100% NPK+ trash	0.0602	0.0749	0.0694	0.0648	0.0802	0.0771	0.730	1.000	0.616	0.750	1.088	0.685
T_3	75% NPK+25% N (CSPM)	100% NPK+ trash	0.0610	0.0755	0.0705	0.0654	0.0842	0.0779	0.721	0.992	0.610	0.746	1.069	0.680
T_4	100% NPK	75% NPK+ GM	0.0623	0.0802	0.0729	0.0631	0.0789	0.0744	0.740	1.028	0.625	0.715	1.033	0.670
T_5	75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	0.0631	0.0842	0.0748	0.0667	0.0881	0.0792	0.767	1.047	0.642	0.775	1.106	0.712
T_6	75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	0.0644	0.0867	0.0762	0.0675	0.0906	0.0807	0.753	1.032	0.638	0.768	1.090	0.698
T_7	50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	0.0567	0.0730	0.0671	0.0577	0.0751	0.0694	0.705	0.984	0.598	0.685	0.965	0.665
T_8	50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	0.0589	0.0746	0.0679	0.0597	0.0770	0.0721	0.693	0.965	0.579	0.703	0.950	0.630
T_9	50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	0.0547	0.0711	0.0644	0.0619	0.0785	0.0742	0.675	0.960	0.571	0.731	0.967	0.670
T_{10}	100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	0.0667	0.0896	0.0802	0.0693	0.0933	0.0848	0.782	1.060	0.658	0.794	1.080	0.718
	SEm±		0.0005	0.0007	0.0007	0.0006	0.0007	0.0006	0.007	0.007	0.005	0.009	0.009	0.009
	CD (P=0.05)		0.001	0.002	0.002	0.0018	0.0021	0.0018	0.022	0.020	0.016	0.027	0.027	0.026

BF-Biofertilizer, VC-vermicompost, GM-Green manuring, CSPM-Carboneous sulphitation pressmud, FYM-Farm yard Manure.

treatments. Differences between T_2 and T_3 and T_1 and T_4 were not significant. T_7 exhibited minimum value (21.2); being at par with that of T_8.

Effect of INM on the yields in sugarcane plant and ratoon crops

Biological yield : Highest biological yield (107.1 t/ha) was noted in T_{10} being at par with T_5 or T_6 but significantly higher than rest of the treatments. Differences between T_2 and T_3 were not significant. T_1 recorded significantly lower value (85.5 t/ha) though at par with that of T_9 or T_8 or T_7. T_{10} significantly exhibited higher biological yield (109.1 t/ha) of ratoon crop which was at par with T_5 and T_6 but was superior to T_7 (81.9 t/ha), followed by T_8 and T_4. Yield obtained under above treatment was 25.2, 24.5 and 22.1 per cent higher than that of T_1, T_4 and T_9, respectively in plant crop and 16.9, 21.7 and 19.8 per cent higher in ratoon crop, respectively. Higher biological yield of plant and ratoon crop under above treatment is attributed to more green tops and trash yield apart from higher cane yield. Green top yield under T_{10} was 23.7 and 16.6% higher than that of T_1 in plant and ratoon crops, respectively. Respective values were 10.9 and 10.6 t/ha in plant and ratoon crop under T_{10}. Higher yield under above treatment may also be attributed to more nutrient uptake.

Dry matter yield in cane : T_{10} resulted in maximum dry mater yield in cane (28.70 t/ha) though at par with that of T_5 or T_6. The differences under T_1 and T_2 or T_3 were not significant but significantly superior to T_8 which gave lowest dry matter (24.07 t/ha). Differences between T_7 and T_9 were non-significant. The highest dry matter yield in ratoon crop (25.83 t/ha) was recorded with T_{10}, which was at par with T_5 and T_6. However, T_7 exhibited minimum cane dry matter yield (22.50 t/ha).

Dry matter yield in green tops : T_{10} exhibited significantly more dry matter accumulation in green tops (5.79 t/ha) but at par with T_5 or T_6. However, T_8 exhibited minimum dry matter accumulation (3.40 t/ha); being at par with T_9 or T_7 which resulted in lower dry matter than that of T_1 (4.64 t/ha). The differences between T_2 and T_3 were not significant. T_{10} resulted in significantly higher green tops dry matter yield (5.95 t/ha) in ratoon crop which was at par with that of T_5 and T_7. However, T_8 exhibited lowest green tops dry matter yield (4.27 t/ha); being at par with T_7.

Dry matter yield in trash : Maximum dry matter (8.95 t/ha) in trash was noted under T_{10} though at par with T_5 or T_6 but was superior to rest of the treatments. T_8 resulted in lowest dry matter accumulation in trash

(5.40 t/ha) being at par with that of T_9. T_1 resulted in higher dry matter in trash (7.71 t/ha) as compared to T_2 or T_3. T_{10} resulted in significantly higher trash dry matter (8.28 t/ha); being at par with T_5, T_6 and T_3 but was higher than rest of the treatments. However, lowest value (5.87 t/ha) was recorded with T_8, being at par with T_7 and T_9. Differences between T_1 and T_4 were also significant. T_{10} produced higher dry matter (43.44 t/ha) in plant crop accounting 28.70, 5.79 and 8.95 t/ha and 40.05 t/ha in ratoon accounting 25.82, 5.95 and 8.28 t/ha from cane, green tops and trash, respectively.

Effect of INM on the nutrient content in sugarcane plant and ratoon crops

Nitrogen content in cane, green tops and trash : Nitrogen content was more in green tops, followed by trash and then cane, irrespective of treatments. T_{10} exhibited significantly higher N content of 0.550, 0.935 and 0.542 %, however, T_9 recorded the lowest values of 0.402, 0.705 and 0.429 % in cane, green tops and trash, respectively. The differences between T_3 and T_1 were significant, except in trash. T_{10} recorded significantly higher N concentration of 0.570, 0.856 and 0.585 % in cane, green tops and trash, respectively in ratoon crop. However, differences in N content between T_2 and T_3; T_4 and T_9 and T_5 and T_6 were not significant. Ratoon crop exhibited lowest N concentration of 0.420, 0.625 and 0.439 % in cane, green tops and trash, respectively under T_8, though at par with that of T_7 in green tops only.

Phosphorus content in cane, green tops and trash : T_{10} significantly exhibited higher P content of 0.0667, 0.0896 and 0.0802 % in cane, green tops and trash, respectively as compared to other treatments. However, minimum P content of 0.0547, 0.0711 and 0.0644 % was noted in cane, green tops and trash, respectively under T_9. Differences between T_1 and T_3 were, however, non-significant. T_{10} gave higher P concentration of 0.0693, 0.0933 and 0.0848 % in cane, green tops and trash, respectively in ratoon crop. Whereas, minimum P concentration of 0.577, 0.0751 and 0.0694 % was recorded in cane, green tops and trash, respectively under T_7. The differences between T_1 and T_4 and T_4 and T_9 were not significant.

Potassium content in cane, green tops and trash : T_{10}; being at par with T_5 recorded significantly higher K (0.782, 1.060 and 0.658 %) in cane, green tops and trash, respectively than that of T_9 which exhibited lowest K content of 0.675, 0.960 and 0.571 % of cane, green tops and trash, respectively. Differences between T_1 and T_2 or T_3 were not significant. T_{10} resulted in higher K concentration (0.794 and 0.718 % in cane and trash, respectively) in ratoon crop. Lowest K concentration (0.950 and 0.630 % in green tops and trash, respectively) was observed under T_8. Minimum K concentration (0.685 %) in cane was under T_7. Differences between T_4 and T_6 were significant but differences between T_2 and T_3 were not significant. Higher nutrient concentration in different plant parts under above treatment might be due to increased nutrients concentration in soil solution owing to better soil condition for plant growth.

From this study, it might be concluded that integrated nutrient management improved growth, yield and nutrient content of sugarcane plant-ratoon cropping system exhibiting superior performance under T_{10}.

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