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Effect of integrated nitrogen management on sugar and sugarcane productivity

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Abstract

Field experiments were conducted during autumn and spring season for three consecutive years at Genda Singh Sugarcane Breeding & Research Institute, Seorahi, Kushinagar (U.P.) to find out the possibility of using organic manures, pressmud cake PMC), FYM (Farm Yard Manure) and bio-fertilizers integrated with different levels of nitrogen and in different proportions for sustaining the sugarcane and sugar productivity. Integrated use of organic manures with chemical fertilizers had the capacity to sustain the sugarcane and sugar production. The use of 2 t/ha PMC + 140 kg N/ha and 4 t/ha PMC + 100 kg N/ha increased the cane and sugar yield over 180 kg N/ha alone and gave an economy of 40-80 kg N/ha. Similar performance was also recorded by the soil application of Mycorhiza alone @ 6 kg/ha or in combination with Azosprillum @ 4kg/ha. The judicious application of organic manure in 1:2 ratio (Organic manure:inorganic fertilizer nitrogen) was found optimum and in combination with Azotobacter @ 6 kg/ha, this ratio increased cane yield by 40.31% over 100% inorganic nitrogen.

Key words: Integrated, pressmud, bio-fertilizers, Azotobacter

Introduction

In India sugarcane is a major commercial crop that sustains sugar industry - the second largest next to cotton and textile industry. State of Uttar Pradesh, which ranks first in the country with regard to area as well as production, contributes to the lower national sugarcane productivity and, therefore, the state's role in improvement of national sugarcane productivity is obvious. Sugarcane produces large quantity of biomass and thus naturally removes the nutrients in proportional quantities. The nutrients need replenishment through the addition of manures and fertilizers in the soil. In the present era of energy crisis with increasing prices of chemical fertilizers coupled with concerned about ecological stability, alternative strategies for long-term sustainability of soil productivity alongwith environmental protection are the major concerns. Chemical fertilizers have the capacity to supply only one or two plant nutrients. Organic manures supply number of macro and micro-nutrients essential for healthy growth and development of sugarcane. For sustainability in sugarcane and sugar production, neither chemical fertilizer nor organic manures alone but their integrated use has been observed to be highly beneficial (Naik and Ballal 1968; Bangar et al., 1994; Chaudhary and Sinha, 2001). Therefore, the present experiments were under taken to bring out the possibility of using organic manures, pressmud cake, farm yard manure and bio-fertilizers integrated with different levels of nitrogen and in different proportions for sustaining the sugarcane productivity.

Materials and Methods

Two sets of experiments were carried out at the research farm of Genda Singh Sugarcane Breeding & Research Institute, Seorahi, Kushinagar (U.P.) for three consecutive years. The experimental sites were sandy loam in texture, calcareous in nature, moderately alkaline in reaction (pH 8.2-8.8), low in organic carbon (0.40-0.48%), low to medium in available phosphorus (8-24 kg/ha) and medium in potassium (125-137 kg/ha). Field experiment on pressmud cake was conducted during the autumn cropping season of 2003-2005, 2004-2006 and 2005-2007. The treatments comprised of 20 combinations of PMC and chemical nitrogen fertilizers, and different bio-fertilizers. Among combinations of PMC and chemical nitrogen fertilizer, 0, 2, 4, 6, 8 ton PMC was applied with 180, 140, 100, 60, 20 kg N/ha, respectively and biofertilizers used were control (no culture), Mycorrhiza @ 6 kg/ha, Azospirillum @ 4 kg/ha and combination of Mycorhiza and Azospirillum. The experiment was designed in split

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plot design keeping combinations of pressmud cake and chemical nitrogen fertilizer in main plot and different biofertilizer in sub plot with three replications. Sugarcane variety CoSe 92423 was planted during autumn season in the first fortnight of October.

Another experiment for curtailing the fertilizer doses was conducted during spring cropping season of 2004-2005, 2005-2006 and 2006-2007. The experiment was arranged in randomized block design with 3 replications comprising 9 treatments. The treatment consisted of combinations of PMC and FYM with inorganic nitrogen fertilizer in 1:1 ratio, 1:2 ratio with Azotobacter @ 6 kg/ha, 2:1 ratio and a control (150 kg N/ha through urea). Spring cane (CoSe 92423) was planted in first fortnight of February.

PMC or FYM and 1/3rd of nitrogen through urea as per treatment; and 60 kg P_2O_5 and 40 kg K_2O were applied in furrows before planting and remaining 2/3rd of nitrogen was applied in two equal splits at proper moisture level upto June. Biofertilizers were mixed separately with 500 kg of FYM incubated overnight and applied to the soil as per treatment schedule in the vicinity of root zone at 45 and 75 days after planting during autumn, and at 30 and 60 days after planting during spring in two equal installments followed by slight earthing up. Recommended cultivation practices were followed for raising the crop.

Results and Discussion

Effect of pressmud cake

In increasing sugarcane yield and subsequent ratoons alongwith environmental protection, organic manuring through the application of industrial waste material like PMC to sugarcane has been found to be of greater importance. About 5.24 million tones of pressmud cake are being produced every year as by-product during the manufacture of white sugar, which is rich in plant nutrient containing 25-30% organic carbon. Besides, it also provides a favourable effect on sugar yield due to high content of phosphorus (Singh et al., 1986). The sulphitation pressmud cake contains 2.4% total P_2O_5 and 1.3% total nitrogen with high electrical conductivity (Table 1).

Table 1. Initial properties of PMC.

Parameters	Values	Parameters	Values
pH	6.38	Total P_2O_5 (%)	2.45
EC (dS/m)	2.79	Total K_2O (%)	0.64
organic carbon (%)	27.0	Total N (%)	1.31
C:N ratio	20.38		

Results of this study showed that combined use of 140 kg N/ha and 2 t/ha PMC resulted in significantly higher cane yield and produced 9.9% higher cane yield to that obtained with only 180 kg N/

Table 2. Yield of sugarcane, sucrose content and CCS yield as influenced by pressmud cake inorganic nitrogen and biofertilizers (Pooled data of 2003-05 to 2005-07).

Treatment (PMC and N Mean levels, kg/ha)	Cane yield (t/ha)					Sucrose (%)					CCS (t/ha)				
	Control	Mycorrhiza	Azospirillum	Mycorrhiza+ Azospirillum	Mean	Control	Mycorrhiza	Azospirillum	Mycorrhiza+ Azospirillum	Mean	Control	Mycorrhiza	Azospirillum	Mycorrhiza+ Azospirillum
0t+180 kg	94.94	110.25	98.40	108.52	103.03	15.84	15.83	15.85	15.88	15.85	10.33	11.97	10.73	11.85	11.22
2t+140 kg	108.52	117.65	109.88	116.91	113.24	16.85	16.13	16.37	16.47	16.45	12.71	13.02	12.48	13.18	12.85
4t+100 kg	97.98	112.35	100.00	110.86	105.25	16.26	16.43	16.77	17.04	16.62	10.95	12.64	11.57	13.03	12.05
6t+60 kg	91.36	103.09	92.35	99.75	96.64	16.79	16.59	16.15	16.42	16.49	10.76	11.91	10.07	11.20	10.99
8t+20 kg	89.14	101.11	92.22	90.74	93.30	16.29	16.27	16.24	16.67	16.37	10.35	11.33	9.97	10.51	10.54
Mean	96.35	108.89	98.57	105.36		16.41	16.25	16.28	16.50						
SEm ± (PMC+N)								NS					1.00		
CD (P=0.05)			6.23												
SEm ± (Biofertilizer)								NS					0.87		
CD (P=0.05)			4.38												

ha (Table 2). This was probably due to use of PMC with higher doses of chemical N could have resulted in favourable soil physical conditions, enhanced microbial activity besides supplying nutrients with increased recovery % of especially N. Similar increase in cane yield was obtained earlier with PMC (Patil and Kale, 1983 and Yaduvanshi and Yadav, 1991). Curtailing the inorganic nitrogen levels and increasing PMC doses, beyond 100 kg N/ha and 4t/ha PMC, could not sustained the cane yield and 6.2 and 9.44 % reduction in cane yield was observed with the combined use of 60 kg N/ha + 6 t/ha PMC and 20 kg N/ha + 8 t/ha PMC, respectively, compared to that obtained with only 180 kg N/ha. This might be due to lower doses of chemical fertilizers could not maintain the availability and supply of nutrients to crop which might cause reduction in yield.

Use of 140 kg N/ha + 2 t/ha PMC increased the cane yield significantly over 180 kg N/ha alone and 100 kg N/ha + 4 t/ha PMC gave at par cane yield to 180 kg N/ha alone, suggesting saving of 40 to 80 kg N/ha of inorganic nitrogen. An economy of nitrogen in sugarcane has been obtained through the use of PMC (Kanwar et. al., 1987, Yaduvanshi et.el., 1990).

Biofertilizers, i.e. Mycorrhiza alone or in combination with Azospirillum recorded significantly higher cane yield compared to control and Azospirillum (Table 2). The cane yield increased by 13.01 and 9.35% over that of control with use of Mycorrhiza alone or in combination with Azospirillum, respectively. Nitrogen fixing micro-organisms fix the atmospheric nitrogen and convert it into an utilizable form for sugarcane (Patil and Hapase, 1981). Similar trends in cane yield due to bio-fertilizers have been reported by Ilangoran et.al., (1995) and Singh[b] et.al. (1995).

Sugar yield followed the same trend as that of sugarcane yield (Table 2). The use of 140 kg N/ha with 2 ton of PMC, being at par with 100 kg N/ha and 4 ton of PMC improved the sugar yield significantly over rest of combinations of PMC and nitrogen. Application of Mycorrhiza alone resulted in significantly higher sugar yield compared to use of Azospirillum and control, however, it was at par with combined use of Mycorrhiza + Azospirillum. Integrated use of 140 kg N and 2 ton PMC alongwith Mycorrhiza alone or with Azospirillum was more effective. It was due to balanced absorption of nutrients. Such improvement due to PMC has been reported by Singh et al., (1986) and Singh (1993).

Effect of organic manures

Fertilizers, among various inputs of sugarcane production, contribute maximum to the increase in yield but this can't help to maintain and enhance soil's organic matter content which is the ultimate key to sustainability. The judicious application of organic manure in 1:1 and 1:2 (Organic manure : inorganic fertilizer nitrogen) ratio resulted in higher cane yield (Table 3). However, use of organic manure in 1:1 ratio in practice is a difficult process, hence 1:2 ratio may help in best utilization of available moisture and increase the efficiency of applied fertilizer.

This study revealed that the sugarcane yield obtained with the combined use of organic and inorganic sources with or without biofertilizer was significantly higher to that obtained with only 100 % inorganic nitrogen (Table 3).

Use of organic manure in 1:2 ratio (organic manures:inorganic fertilizer nitrogen) alongwith Azotobacter @ 6 kg/ha resulted in comparable cane yield to organic manure applied in 1:1 ratio. Percent increase in cane yield over 100% inorganic nitrogen was 40.31% with 1:2 ratio alongwith use of Azotobacter and 21.77% without use of Azotobacter. Organic manures applied in 1:1 ratio could give upto 43.77% increase in cane yield over chemical fertilizer alone. A large numbers of workers (Singh[b] et.al., 1995; Bangar and Sharma, 1997; Chaudhary and Sinha, 2001) reported synergistic interaction among organic manures and inorganic nitrogen which modified the quantum of nutrient uptake by plants as their effect is

Table 3: Yield and quality of sugarcane as influenced by organic and inorganic fertilizers (Pooled data of 2004-05 to 2006-07).

Treatments (Organic manure: Inorganic N fertilizer)	Cane yield (t/ha)		Sucrose (%)		CCS yield (t/ha)	
	PMC	FYM	PMC	FYM	PMC	FYM
1:1	90.5	96.4	16.7	16.8	10.53	11.28
1:2	77.0	81.3	16.8	17.7	9.02	9.98
1:2 with Aztobacter @ 6 kg/ha	88.1	94.3	17.3	17.4	10.50	11.33
2:1	71.6	73.5	17.3	17.3	8.51	8.75
Control (150 kgN/ha through urea)	65.0	17.1	7.68			
SEm ± CD (P=0.05)	6.37	NS	0.98			

not merely added up but is actually enhanced. It was also found that FYM was more effective than PMC in increasing cane yield.

Almost similar trend was also found with sugar yield as that of sugarcane yield (Table 3). Organic manure applied in 1:2 ratio alongwith Azotobacter @ 6 kg/ha and 1:1 ratio, being at par, improved the sugar yield significantly over use of organic manure in 1:2 ratio without Azotobacter, 2:1 ratio and chemical fertilizer alone. Bangar and Sharma (1997) reported as much sugar yield by application of 75% of inorganic fertilizers alongwith Azotobacter as with inorganic fertilizer alone.

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