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APPRAISAL OF PRESSMUD AND INORGANIC FERTILIZERS ON SOIL PROPERTIES, YIELD AND SUGARCANE QUALITY

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Abstract

A field experiment was conducted under semi-arid climatic conditions to evaluate the response of pressmud in combination with inorganic fertilizers and alone (only inorganic fertilizers) on the yield and sugarcane quality parameters besides a value-added product (locally called Gur). It is obvious from the results that inorganic fertilizer use (T_2) has increased the tillers per plant, number of millable canes, stripped cane yield, sugar yield and juice present cane by 38.95 %, 38.66 %, 51.96 %, 54.92 % and 21.9 5% respectively, over the control (T_1). Similarly when higher dose of pressmud was applied in integration with inorganic fertilizers (in T_3), it increased total soluble solids, sucrose, purity, CSS and sugar recovery of juice by 7.83 %, 10.42 %, 2.80 %, 12.06 %, and 12.07 %, over the control (T_1). The studies concluded that higher doses of mineral fertilizers increased gur % juice but it did not improve gur quality as done by higher doses of organic manures. Soil properties were also investigated before and after crop harvest. Maximum fertilizer use efficiency (124.29) was recorded in T_2.

Introduction

Sugarcane is a long duration exhaustive crop (Paul *et al.*, 2005). It has been found that 85 tons of crops remove 122.24 and 142 kg NPK ha^{-1}, respectively from soil (Bokhtiar *et al.*, 2001). One of the main constraints for its good yield is its high nutritional requirements along with increased cost of fertilizers (Gholve *et al.*, 2001). Similarly, spiralling prices coupled with short availability of fertilizers (Khandagave, 2003) and depletion of available nutrients and organic matter due to continuous cane cropping with inorganic fertilizers (Kumar & Verma, 2002; Ibrahim *et al.*, 2008; Sarwar *et al.*, 2008a) necessitates the integrated use of organic and mineral fertilizer resources.

Pressmud can serve as a good source of organic manure (Bokhtiar *et al.*, 2001) an alternate source of crop nutrients and soil ameliorates (Razzaq, 2001). Dry matter, cane and sugar yields increase with increasing nitrogen and pressmud cake rates (Bangar *et al.*, 2000). The integrated use of pressmud and urea 1:1 ratio at 180 kg ha^{-1} is beneficial for cane crop in calcareous soil (Sharma *et al.*, 2002). Filter cake increases cation exchange capacity for thirty months after its application (Rodella *et al.*, 1990) and its residual effect remains after four years (Viator *et al.*, 2002). Sharma *et al.*, (2002) recorded an increase in number of millable canes and yield when pressmud and urea were added in 1:1 ratio than pressmud alone. Tiwari *et al.*, (1999) noticed that application of pressmud at 6 t ha^{-1} increased cane and sugar yield while its application at 4 t ha^{-1} plus 5 kg *Azotobacter* ha^{-1}

produced analogous results to 6 t pressmud alone. Keeping in view the situation, the present investigations were performed to appraise and compare the efficiency of pressmud along with inorganic fertilizers.

Materials and Methods

Field trial was conducted at farmer's field to evaluate and explore the integrated role of inorganic fertilizers and pressmud in sugarcane. Early maturing cane variety HSF-240 was sown at 80,000 double bud sets (DBS) ha^{-1} in deep trenches during the first week of March, 2005 and harvested in February, 2006. The same sowing and harvesting schedule was repeated during 2006-07 in randomized complete block design having three replications as tabulated in Table 1. Pressmud obtained from the nearby sugar factory, containing N_2 (2.30 %), P_2O_5 (1.35 %) and K_2O (0.75 %), was applied in field before sowing. Single super phosphate (SSP) and K_2SO_4 were applied at sowing in deep trenches while, urea was applied in three equal splits at 0, 45 and 90 days after plantation. Soil samples were collected before sowing and after harvesting to analyze its fertility status for pH, EC_e, organic matter (OM), organic carbon (OC), nitrogen (N_2), potassium (K), bulk density (BD), exchangeable sodium (Na), exchangeable calcium (Ca) by the methods described by Richard (1954) and phosphorus (P) by Olsen *et al.*, (1954).

Recommended plant protection measures like weeding, irrigation and hoeing *etc.* were carried out when considered necessary and all the cultural practices were same for all the treatments. The data regarding germination and tillering were noted after 45 and 90 days of sowing while number of millable canes, stripped cane and sugar yield at harvest. Three stools were selected randomly from each treatment to determine juice quality according to sugarcane Laboratory Manual for Queensland Sugar Mills (Anonymous, 1970). Similarly gur was prepared and analyzed according to methods described in Gur Monograph (Roy, 1951). The data thus collected were statistically analyzed according to procedures outlined by Steel & Torrie (1980).

Results and Discussion

Germination: The data indicated that difference in treatments were non significant for germination (Table 2). The maximum germination (47.96 %) was registered by T_3 followed by T_4 (47.92 %), T_5 (47.89 %), T_1 (47.70 %), T_6 (47.67 %) and T_2 (47.40 %) in descending order. The results indicated that cane sets' germination was not affected by different fertilizer treatments. However the lowest germination in T_2 might be due to higher dose of mineral nitrogen that depressed germinants by ammonia production due to urea hydrolysis (Verma *et al.*, 1985). These results are also confirmed by the findings of Majeedano *et al.*, (2003) who also recorded non-significant germination in treatments of fertilizer application.

Tillers per plant: The data indicated significant variation for tillering among all treatments (Table 2). T_2 produced highest tillers per plant (1.72) while T_1 produced the lowest values (1.05). The highest tillering in T_2 might be due to quick availability of inorganic nutrients as well as more space availability due to presence of less germinant in it. Similarly the lowest tillers per plant in T_1 (control) was due to non availability of nutrients as no fertilizer was applied. These discussions are in harmony with those elucidated by Aslam & Chattha, (2005).

Table 1. Treatments description.

Treatments	Organic source pressmud (PM) Mg ha^{-1}	Inorganic sources
T_1	0	0
T_2	0	168-112-112 NPK kg ha^{-1}
T_3	7.3 Mg ha^{-1} *i.e.* 100 % N_2 through PM (168-98.5-54.74 NPK kg ha^{-1})	0-13.5-57.25 NPK kg ha^{-1}
T_4	5.48 Mg ha^{-1} *i.e.* 75 % N_2 through PM (126-74-41 NPK kg ha^{-1})	42-38-71 NPK kg ha^{-1} *i.e.* 25 % N_2 through inorganic source
T_5	3.65 Mg ha^{-1} *i.e.* 50 % N_2 through PM (84-49.28-27.38 NPK kg ha^{-1})	84-62.72-84.62 NPK kg ha^{-1} *i.e.* 50 % N_2 through inorganic source
T_6	1.83 Mg ha^{-1} *i.e.* 25 % N_2 through PM (42-24.70-13.73 NPK kg ha^{-1})	126-87.3-98.27 NPK kg ha^{-1} *i.e.* 75 % N_2 through inorganic source

Number of millable canes: The data pertaining to number of millable cane elucidated that all treatments varied significantly among each other (Table 2). The maximum millable canes were recorded in T_2 (114,000/ha) while minimum in T_1 (70,000/ha) T_3 and T_4 were statistically at par with each other. The maximum number of canes in T_2 was due to high tillering as well as ready availability of mineral fertilizers. These results are similar to the findings of Hussain *et al.,* (2005) who, in a fertilizer experiment, proved that higher tillering gave rise to higher number of millable canes.

Stripped cane yield: Statistically significant differences for cane yield among various treatments were confirmed (Table 2). Thus a trend similar to the tillers per plant and number of millabel canes was observed. The highest canes were yielded by T_2 (93.77 Mg ha^{-1}) and it was followed by T_6 (86.67 Mg ha^{-1}), T_5 (83.81 Mg ha^{-1}), T_4 (72.32 Mg ha^{-1}) T_3 (70.65 Mg ha^{-1}) and T_1 (45.05 Mg ha^{-1}) in descending order. The results indicated that highest tillering and highest cane count produced maximum cane yield. These results are also supported by Perumal (1999) who concluded that inorganic fertilizer increased cane yield while comparing organic and inorganic fertilizers (Viator *et al.,* 2002).

Sugar yield: It is obtained by multiplication of CCS with cane yield. Significant differences in sugar yield were found. Maximum sugar yield (12.40 Mg ha^{-1}) was recorded it T_2 and it was followed by T_5 (11.56 Mg ha^{-1}), T_6 (11.55 Mg ha^{-1}), T_4 (10.13 Mg ha^{-1}), T_4 (9.96 Mg ha^{-1}) and T_1 (5.59 Mg ha^{-1}). T_3 and T_4 as well as T_5 and T_6 were statistically at par with each other (Table 2). El-Geddawi *et al.*, (1988) concluded that higher cane yield produced higher sugar also. Similarly, Ahmed *et al.*, (1998) observed that sugar yield increased with increasing plant density and nitrogen rate.

FUE: The data regarding fertilizer use efficiency (FUE) presented in (Table 2) indicated that T_2 showed the highest FUE (124.29 kg kg^{-1}) compared with pother treatments. The comparison with control also indicated that FUE had increased with increasing the amount of pressmud in the treatments.

Total soluble solids: A glance at data given in Table 3, it is evident that total soluble solids differed statistically from each other. The maximum value (21.70 %) was obtained in T_3 where no mineral nitrogen, but all organic nitrogen was applied. T_4 and T_5 were statistically at par with it. However the use of heavy dose of mineral nitrogen decreased total soluble solids as in T_2 (21.30%). This might be due to dilution caused by heavy dose of mineral nitrogen or due to increase in ash in cane juice. Similar findings were claimed by Bangar *et al.*, (1994) who proved that increasing pressmud cake increased juice brix.

Table 2. Effect of pressmud and inorganic fertilizers on agronomic characteristics of cane crop.

Treatments	Germination (%)	Tillers per plant	No. of millable canes (000/ha)	Stripped cane yield (Mg ha^{-1})	Sugar yield (Mg ha^{-1})	FUE (kg kg^{-1} of NPK)
T_1	47.70	1.05d	70e	45.05d	5.59d	-
T_2	47.40	1.72a	114a	93.77a	12.40a	124.29
T_3	47.96	1.12d	72de	70.65c	9.96c	65.31
T_4	47.92	1.15cd	76d	72.32c	10.13c	69.57
T_5	47.89	1.32bc	87c	83.81b	11.56b	98.88
T_6	47.67	1.42b	92b	86.67b	11.55b	106.17
LSD at 5 %	N.S.	0.199	4.881	4.881	0.695	

Sucrose: A perusal of tabulated data indicated almost similar trend as that of total soluble solids. The maximum sucrose (18.81 %) was obtained in T_3 and it was statistically at par with T_4, while T_4 and T_5 were also statistically at par. Similarly T_6 and T_2 were statistically at par. The results showed that organic nitrogen increased sucrose while inorganic depressed it. Bangar *et al.*, (1994) also reached similar conclusion that fertilizer nitrogen decreased sucrose.

Purity: Statistically significant and maximum purity was obtained in T_3 (86.68 %) and T_4 and T_5 were also statistically at par with it. Similarly T_6, T_2 and T_1 were also at par. The similar trend of highest and lowest values was recorded as in total soluble solids and sucrose as indicated by Mohammad (1989), that decreases in purity percentage depended upon sucrose and brix values. Similar conclusion was drawn by Banger *et al.*, (1994) while comparing organic nitrogen fertilizer with pressmud.

CCS and sugar recovery: These two parameters are directly proportional to each other because sugar recovery is calculated from CCS. Here the similar trend of maximum and minimum values was recorded as in case of total soluble solids, sucrose and purity. T_3 produced maximum CCS and sugar recovery (14.10 and 13.26) while T_2 ranked second lowest before control. These results are in conformity with the findings of Bangar *et al.*, (1994).

Ash: The results regarding ash% Juice and ash % gur are depicted in Table 2 and Table 3. Non significant differences were recorded for ash % (juice) indicating the maximum ash% in T_2 (0.58) where only inorganic fertilizers were applied. The increasing dose of organic fertilizers decreased ash % in juice. Similar but significant trend was recorded for ash % gur. This showed that higher concentration of ash in juice also increased ash in gur and higher concentration of ash in juice was directly proportional to higher doses of mineral fertilizers. These results of ash % juice are contrary to Banger *et al.*, (1994) who concluded an increase in ash with increasing pressmud. But these results are analogous to Hussain *et al.*, (2007) who proved that higher concentration of ash in gur was due to its higher concentration in juice.

Table 3. Effect of pressmud and inorganic fertilizers on agronomic characteristics of cane crop.

Treatments	Total soluble solids (%)	Sucrose (%)	Purity (%)	CCS (%)	Sugar recovery (%)	Ash %	Reducing sugars (%)	Juice % cane
T_1	20.00d	16.85d	84.25c	12.40c	11.66c	0.25	0.63	52.03e
T_2	21.30c	17.96c	84.32b	13.22b	12.43b	0.58	0.52	66.66a
T_3	21.70a	18.81a	86.68a	14.10a	13.26a	0.29	0.34	54.28de
T_4	21.60ab	18.70ab	86.57a	14.01a	13.17a	0.35	0.40	57.21cd
T_5	21.53ab	18.50b	85.92a	13.80a	12.97a	0.42	0.45	61.55bc
T_6	21.45bc	18.10c	84.39b	13.33b	12.53b	0.53	0.49	64.58ab
LSD at 5 %	0.181	0.263	1.304	0.315	0.293	NS	NS	4.881

Reducing sugars: The data relating reducing sugars in juice and gur is described in Table 3 and Table 4. Non significantly varied reducing sugars in juice showed that highest percentage of reducing in juice showed that the highest percentage of reducing sugars (0.63%) was recorded in T_1 (control) while the minimum in T_3 (0.34%). The higher reducing sugars in T_1 were due to un-ripened cane as well as low recovery, while the lower reducing sugars in T_3 (0.34%) were due to higher purity, CCS and sugar recovery. Nearly similar trend was studied by Hussain *et al.*, (2007) in their studies when they found that higher reducing sugars in juice also increased its concentration in gur.

Table 4. Effect of pressmud and inorganic fertilizers on gur quality.

Treatments	Gur % cane	Gur % Juice	Ash	Reducing sugars (%)
T_1	9.89d	19.01d	2.05c	4.01a
T_2	13.51a	20.27c	2.70a	3.65b
T_3	11.21c	20.66a	2.53ab	3.05d
T_4	11.76bc	20.55ab	2.36abc	3.17d
T_5	12.61ab	20.48ab	2.30bc	3.29cd
T_6	13.81a	20.40bc	2.12c	3.49bc
LSD at 5%	1.045	0.182	0.359	0.293

Juice % cane: A perusal of data given in Table 3 indicated that the maximum juice % cane was extracted from T_2 (66.66 %) and it was statistically at par with T_6 (64.58 %). T_1 (control) produced lowest juice % cane (52.03). These results revealed that cane yield and juice % cane had direct relation with each other as higher cane yield supported higher juice % cane and *vice versa*. Hussain *et al.*, (2007) also studied variable juice % cane in different varieties.

Gur % cane and juice: Significant differences among all treatments were noticed for these two parameters. Maximum gur % cane was notice in T_2 (13.51 %) and was followed by T_6 (13.18 %), T_5 (12.61 %), T_4 (11.76 %) T_3 (11.21 %) and T_1 (9.89 %) in descending order (Table 4). Similarly maximum gur % juice was registered by T_3 (20.66 %) and it was followed by T_4 (20.55 %), T_5 (20.48 %), T_6 (20.40 %), T_2 (20.27 %) and T_1 (19.01 %) in descending order. Hussain *et al*., (2007) also investigated such studies.

Soil analysis: The physio-chemical properties of soil after crop harvest are described in Table 5. The results of P revealed that highest P was found in the inorganic fertilizer application treatment. It was so justified because P from inorganic source was readily available. Among the organic manure treatments, results varied but were quite insignificant. As far as K was concerned, its concentration showed variation but it remained non significant. Organic carbon, organic matter and N concentration were interlinked and were well justified with the highest value in that treatment which had 100 % N by organic matter followed by those of 75 % and 50 % N by organic source. 100 % organic source application created a sound decreased in bulk density and thus helped in making soil structure better. The pH had no significant effect but a little decrease of pH was found in those treatments where PM was applied. Exchangeable Na also increased with application of treatments but this change was significant in synthetic fertilizer applied treatments while on treatment had lesser increase as compared to T_2. Exchangeable Ca increased with application of treatments but it was significant in PM application treatment while synthetic fertilizer also raised this concentration but it was not significant as compared to PM treatments (Sarwar *et al*., 2008b).

Table 5. Physio-chemical characteristics of soil after crop harvest.

Treatment	OM (%)	OC (%)	N (%)	P (ppm)	K (ppm)	pH	EC_e (dsm^{-1})	Exh. Na (ppm)	Exch. Ca (ppm)	BD Mg/m^3
T_1	0.88	0.51	0.044	5.9ab	110bc	7.7	0.46	119bc	112e	1.45
T_2	0.88	0.51	0.044	6.1a	115ab	7.8	0.42	155cd	130d	1.48
T_3	1.15	0.67	0.058	6.1a	120a	7.7	0.40	111d	158a	1.39
T_4	1.08	0.63	0.054	5.8ab	110bc	7.6	0.39	121b	148b	1.39
T_5	1.01	0.59	0.051	5.7b	100d	7.8	0.39	128a	141c	1.40
T_6	0.99	0.58	0.050	5.7b	105cd	7.7	0.47	130a	139c	1.41
LSD at 5 %	NS	NS	NS	0.3404	5.458	NS	NS	5.529	5.893	NS

OM=organic matter; **OC**=organic carbon; **Exh.Na**=exchangeable Na; **Exh. Ca**=exchangeable Ca; **BD**=bulk density.

Conclusion

Incorporating pressmud into the soil had increased the sugar yield and cane juice quality. For the study period, the bulk density was the minimum in T_4. The mean soil organic carbon concentrations ranged between 0.51 to 0.63 %. It might be assumed that the application of pressmud had increased the OC concentrations in soil along with improving the soil conditions. Additional investigations are needed to compare the direct effects of pressmud on cane juice quality and yield under diverse ecological conditions. Long term studies with the employment of pressmud and other organic sources may prove the worth in soil properties management.

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