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INTEGRATED EFFECT OF INORGANIC AND ORGANIC FERTILIZERS ON THE YIELD AND QUALITY OF SUGARCANE (*SACCHARUM OFFICINARUM* L)

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Abstract

To determine the inorganic and organic nutrient sources & optimum rates for sugarcane production, field experiment was conducted at Agriculture Research Institute, Tandojam, Pakistan, (25°25'60'N 68°31' 60E) during 2008-2009. Sugarcane variety Thatta-10 was planted and following treatments were arranged in RCBD: control (0-0-0), Recommended NPK dose (225-112-168), FYM 10 t ha^{-1}, FYM 20 t ha^{-1}, PM 10 t ha^{-1}, PM 20 t ha^{-1}, BF 5 t ha^{-1}, BF 10 t ha^{-1}, three-fourth of recommended rate (169-84-126)+ FYM 10 t ha^{-1}, three-fourth of recommended rate (169-84-126) + FYM 20 t ha^{-1}, three-fourth of recommended rate (169-84-126) + PM 10 t ha^{-1}, three-fourth of recommended rate (169-84-126) + PM 20 t ha^{-1}, three-fourth of recommended rate (169-84-126) + BF 5 t ha^{-1}, three-fourth of recommended rate (169-84-126) + BF 10 t ha^{-1} , half of recommended rate(112-56-84) + FYM 10 t ha^{-1}, half of recommended rate(112-56-84) + FYM 20 t ha^{-1}, half of recommended rate (112-56-84) + PM 10 t ha^{-1}, half of recommended rate(112-56-84) + PM 20 t ha^{-1}, half of recommended rate(112-56-84)+BF 5t ha^{-1}, and half of recommended rate(112-56-84) + BF 10 t ha^{-1}. The results showed that under-dose or individual application of inorganic or organic nutrient sources recorded less value of all sugarcane traits but the integration of both the sources except bio fertilizer significantly improved all the traits of plant crop. The maximum tillers plant^{-1}, plant height, stem girth, internodes plant^{-1}, internode length, millable canes, cane yield, leaf area plant^{-1}, leaf area index, crop growth rate and dry matter were found higher with the application of FYM and or press mud applied at 20 t ha^{-1} with three-fourth of recommended rate of NPK fertilizer (169-84-126). Both the treatments were statistically non-significant. However, quality and nutrient uptake traits viz. brix, pol, purity, commercial cane sugar, NPK uptake and accumulation in sugarcane were higher with the application of three-fourth of recommended rate of NPK fertilizer (169-84-126^{1}) + 20 tons press mud ha^{-1}. It is concluded that integrated nutrient management recorded 25% saving of inorganic fertilizers with the application of FYM and or press mud applied at 20 t ha^{-1}. Integration of organic and inorganic nutrients should be practiced. This will not only enhance growth, yield, quality and nutrient uptake of sugarcane but also conserve agro-ecosystem for sustainable crop production.

Introduction

Sugarcane (or *Saccharum hybrid*) is an economically important crop. It provides a rich source of sucrose, alcohol and organic matter waste which is utilized as fertilizer. Sugarcane was cultivated vegetatively as noble canes until the end of 20th century. Today sugarcane is known as an aneuploid hybrid crop derived from a cross between *Saccharum officinarum* L., and a wild relative *Saccharum spontaneum*, through the process of Nobilization (Mumtaz *et al.,* 2011).

The use of inorganic fertilizers does not necessarily lead to better farming than the use of natural and organic methods in agriculture. Due to continuous application of only inorganic fertilizers and plant protection chemicals in agriculture, the soils have been badly degraded. It has destroyed stable traditional ecosystem of the soil (Palaniappan & Annadurai, 1999). There is need to encourage more productive, cost efficient and eco-friendly farming system (Bhattacharya & Gehlot, 2003). The use of organic manure has been the need for improving the sustainable productivity of soil. (Singh *et al.,* 2003) depicted that by using integration of 25 and 37.5% N through sulphitation press mud cake and rest through inorganic nitrogen, the inorganic N could be saved from 12.5 to 25% with no loss in cane yield as obtained against the total N application (150 Kg/ha) as inorganic source . However, 50% N through SPMC + 50% through inorganic sources increased the cane yield significantly being 12.05% higher than that of treatment fertilized with 150 kg N/ha as inorganic source alone.

Like micronutrients, farm yard manure (FYM) is also considered as an important source of macro and micronutrients that increase crop yield. Due to higher prices of inorganic fertilizers, farmers in Pakistan couldeasily manage to prepare FYM in their farms and to apply in fields Thus use of Farmyard Manure, Potassium and Zinc should be included in integrated crop management approaches for sustainable agriculture (Nawab *et al*., 2011).

Addition of compost improves soil structure, texture and tilth. Biocomposts have gained importance since the fertilizers and pesticides cause a lot of environmental problems and health hazards and soil degradation (Ghugare *et al.,* 1988). Organic matter is necessary for sustainable crop production (Bhander *et al.,* 1998). Sugarcane is a long duration and exhaustive crop, which produces large quantum biomass, removes considerable amount of nutrients from soil for its normal growth and development. A crop of 100 ton cane yield may remove 140 kg N, 34 kg P and 332 kg K from soil (Dang *et al.,* 1995). Comparisons of multiple organic and inorganic sources are useful nutrient management options that can improve sugarcane yields. Increasing nutrient management options are particularly important during increasing fertilizer prices. Intensive cropping and imbalanced use of essential plant nutrients have rendered the alluvial soils of sub-tropics to be poor in organic carbon content and deterioration in physical properties (Speir *et al*., 2004) lead to restricted growth and development of the crop.

For sustainable crop production, integrated use of chemical and organic fertilizer has proved to be highly beneficial. Several researchers have demonstrated the beneficial effect of combined use of chemical and organic fertilizers to mitigate the deficiency of many secondary and micronutrients in fields that continuously received only N, P and K fertilizers for a few years, without any micronutrient or organic fertilizer. Dutta *et al.,* (2003) reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health. However application of organic manure in combination with chemical fertilizer has been reported to increase absorption of N, P and K in sugarcane leaf tissue in the plant and ratoon crop, compared to chemical fertilizer alone (Bokhtiar & Sakurai 2005). Application of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health (Kumaraswamy *et al.,* 1998). The application of organic matter from such resources as animal manure, crop residues and green manuring has been shown to replenish soil organic C and improve soil fertility (Saviozzi *et al*., 2002; Srivastava *et al*., 2009). Moreover several kind of microbial agents capable of fixing N or mobilizing P and others nutrients are becoming an integral component of Integrated Nutrient Management system of crops.

The application of graded levels of major nutrients, with and without the combinations of micronutrients, vermin-compost and bio-fertilizers totaling fifteen treatments to sugarcane crop (Kanjana, 2007); and highest dose of 340, 80 and 140 kg N, P and K ha^{-1} of N, P and K in combination with micronutrients of 37.5 kg $ZnSO_4$ and 100 kg $FeSO_4$ ha^{-1}), vermin-compost (5 t ha^{-1}) and Azophos (2.4 kg ha^{-1}) maintained higher levels of available nutrients at different stages of crop growth. There was great impact biocompost, farmyard manure (FYM) and press-mud cake (PMC) as well as integration of these organic fertilizers with inorganic N on the growth, yield, quality and leaf N content of sugarcane and soil nutrient status. Among the organics, FYM on equal N basis application increased the shoot population, number of millable canes and yield over others without remarkable change in sugar content of cane. Integrated application of either of the organics with inorganic exhibited better impact on the growth and yield characters and the 50:50 integration proved superior over others, closely followed by 33:67% ratio (Srivastava *et al.,* 2005). However the application of 25% less inorganic fertilizer to the recommended level of chemical fertilizer with press mud or FYM could be used to prevent nutrient depletion and maintain productivity as well (Bokhtiar, *et al.,* 2005).

Organic manures applied to the crop markedly enhance the ratoon cane yield and juice quality and improve the physical conditions of the soil (Singh *et al.,* 2003). Organic fertilizer has residual nitrogen (N) effect after the year of its application to land, as the decomposition of organic material usually takes more than a year (Lund & Doss 1980; Magdoff & Amadon 1980; Gorlitz *et al.,* 1985; Werner *et. al.,* 1985; Sommerfeldt *et al.,* 1988; Dilz *et al*., 1990). Manures can supply nitrogen (N) beyond the year of its application, producing residual effects that are not fully expressed in short-term experiments (Schroder, 2005). Declining soil health and soaring prices of market purchased inputs , intensive cropping and imbalanced use of essential plant nutrients have rendered the alluvial soils of sub-tropics to be poor in organic carbon content and deterioration in physical properties (Speir *et al*., 2004) lead to restricted growth and development of the crop. Keeping this in view the present study was planned to find agro-techniques which on one hand can ensure balanced supply of nutrients for the crop and on the other effectively restore the soil health and also save on the cost of inputs.

Materials and Methods

The soil of experiment was clay loam in texture, EC (0.97 dSm^{-1}), slightly alkaline in reaction pH (7.7), calcareous ($CaCO_3$ 9.5%), low in organic matter (0.6%), total nitrogen content (0.05%) and available phosphorus (3.5 mg kg^{-1}), however high in exchangeable potassium (180 mg kg^{-1}).The experiment was conducted using randomized complete block design , the net plot size was kept $35m^2$ and all the treatments were replicated three times.

Cultural practices: The land was prepared with disc plough to remove the hard pan of the soil and to achieve fine seed bed. The precision land leveling was maintained after bund making and developing plots according to the layout plan. The FYM, sugarcane press mud and bio fertilizer were thoroughly mixed with soil according to treatments i.e. one month before sowing of crop. The ridges were made at row spacing of 1 meter. The sets bearing 2-3 buds of sugarcane variety Thatta-10 were placed in the furrows (overlapping) and covered with thin layer of soil.

A light irrigation was applied immediately after sowing. Later, the crop was irrigated at 15 days interval in winter months and at 8-10 days interval during summer months. Overall, 25 irrigations were applied during the growing season. Fertilizers were applied according to the experimental treatments. Nitrogen, phosphorous and potassium were applied in the form of Urea, DAP and SOP, respectively. Nitrogen was applied in three equal split doses i.e., at the time of sowing, after germination and completion of tillering. All phosphorus and potash were applied at the time of sowing. Two earthings were done both in plant as well as in ratoon crop. Cultural method of weed control was applied through interculturing. Stem borers were controlled by release of *Trichogramma chilonis* (Lshii). Larsben was applied at the rate of 5 lit ha^{-1} with 1^{st} irrigation to control the termites.

The data were statistically analyzed through "Statistix 8.1" computer software. The LSD value for mean comparison was calculated only if the general treatment F test was significant at a probability of ≤ 0.05 (Gomez & Gomez, 1984).

Agronomic observations

Germination (%): At the completion of germination after 45 days of sowing, the number of seedlings emerged in each plot were counted and then converted into percentage by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated buds}}{\text{Total number of buds}} \times 100$$

Plant height (cm): The height of 25 randomly selected plants was measured in centimeters from the surface of soil to the tip of the flag leaf.

Tillers plant^{-1}: Number of the tillers plant^{-1} was recorded after crop emergence and completion of germination.

Stem girth (cm): The stem girth of 25 randomly selected plants was measured in centimeters by Vernier caliper from bottom, mid and top portion and averages of the three data were used for statistical analysis.

Internodes plant^{-1}: At harvest, internodes of 25 randomly selected canes from each treatment were counted. Thereafter, their average was taken.

Internodes length (cm): Length of all internodes of the 25 randomly selected canes from each treatment was recorded. Then average internodes length was calculated.

Millable canes (000 ha^{-1}): A millable cane refers to the cane that has attained full height and thickness at its physiological maturity and is ready to harvest for processing. Number of millable canes in each plot was counted at harvest and then converted into number of millable canes per hectare.

Cane yield (t ha^{-1}): The whole plot was harvested and leaves were removed and cane was cut from the top and the cane of the plot was weight in kg on spring balance and computed for hectare.

Physiological Observations

Leaf area: To record leaf area 25 plants from each treatment were randomly selected, removed from the soil and leaf area was measured manually by using the formula described by Hunt (1978). LA= Leaf length x Leaf width x CF (0.75)

Leaf area index: Leaf area index of twenty five randomly selected plants from each plot was determined through length and breadth method. Leaf area index was calculated by the following formula described by Radford (1967).

LAI = leaf area per plant/ground area per plant.

Dry matter accumulation: Fresh weight – Dry weight

Total dry matter (TDM): was worked out from 25 randomly selected plants from each plot. Thereafter, a sample of 500 g was taken from each treatment, oven dried at 80^{o}C and weighed on digital top loading balance.

Meteorological data: Agro-Meteorological data were noted from Regional Agro-Met Center, Tandojam Sindh, Pakistan.

Nutrient contents

N-content (%): Total N was determined by micro-Kjeldahl digestion on an aluminum digestion block and analysis with a flow analyzer. Leaf samples were also digested with sulphuric acid and perchloric acid 2 h, 150°C) followed by hydrogen peroxide (1 h, 150°C) on an aluminum digestion block.

P-content (%): Total P was determined by nitric acid and hydrogen peroxide digestion and analysis with the phosphomolybdate blue method (Murphy & Riley,1962).

K-content (%): K concentration was determined in the same digestion as in P content by using flame photometer.

N-uptake: Nitrogen uptake was calculated through cane yield x N concentration in plant/(100).

P-uptake: Phosphorus uptake was observed through cane yield x P concentration in plant /(100).

K-uptake: Potassium uptake was observed through cane yield x K concentration in plant / (100).

Results and Discussion

Effect of inorganic and organic nutrients on agronomic traits of plant crop: The results of the experiment revealed maximum germination (58.33%), tillers plant^{-1} (5.83), plant height (266.78 cm), stem girth (2.63 cm), internodes plant^{-1} (16.99), internode length (13.33 cm), millable canes (120.0 thousands ha^{-1}) and cane yield (118.33) of plant crop with the application of FYM @ 20 t ha^{-1} and three-fourth of recommended NPK (169-84-126) and 49.33, 6.55, 278.89, 2.64, 16.22, 14.0, 123.66 and 119.60 respectively with application of press mud @ 20 t ha^{-1} with three-fourth of recommended NPK (169-84.-126 kg ha^{-1}). The mean values of both the treatments were statistically non-significant. The results agree with the findings of Bokhtiar *et al.,* (2005) that cane height up to 3.19 m can be realized from press mud treatments followed by farmyard manure with cane and sugar yield of 199.14 t ha^{-1} and 10.99 t ha^{-1} respectively. The findings of Yadev *et al*., (1993) also supports the results of this study that combined application of cow dung at 20 t ha^{-1} with 50 kg N ha^{-1} increased cane yield. Yield increase in sugarcane, have also been reported by Bevacqua & Mellano (1994); Hallmark *et al*., (1995) with addition of organic amendments to soil.

This study is fully supported by Rakkiyappan *et al*., (2001) that highest cane and sugar yields could be achieved with the application of 75% NPK + pressmud, whereas, combined application of organic and chemical fertilizers significantly enhanced the yield over chemical fertilizers alone, Babar*et al.,* (2011), also found that fifty percent bio-fertilizer + 50% recommended dose of chemical fertilizer increases the cane yield along with reduced environmental pollution.

The results further showed that lower rates or individual application of inorganic or organic nutrient sources recorded less value of all agronomic traits. The minimum germination (49.66%), tillers plant^{-1} (3.3), plant height (210.4 cm), stem girth (2.43- cm), internodes plant^{-1} (12.5), internode length (7.8 cm), millable canes (44.0 thousands ha^{-1}) and cane yield (30.41) were found in untreated plots (Table 1).

Table 1. Effect of inorganic and organic nutrients on agronomic traits of plant crop.

Treatments	Germination (%)	Tillers plant $^{-1}$	Plant height (cm)	Stem girth (cm)	Internodes plant $^{-1}$	Internode length (cm)	Millable canes (000) ha^{-1}	Cane yield (t ha^{-1})
Control (untreated) 0-0-0 NPK kg ha^{-1}	49.66g	3.7 gh	212.4 h	2.43 de	13.77 cde	7.83 g	44.00 i	30.41 i
100% recommended (225-112-168 NPK kg ha^{-1})	55.00 bc	5.33 bc	260.7 bc	2.53 bc	13.88 cde	10.00 cde	96.30 cd	94.81 cd
Farm yard manure 10 t ha^{-1}	50.00 fg	3.88 gh	213.1 h	2.44 cde	12.7 e	9.00 ef	53.50 hi	42.70 hi
Farm yard manure 20 t ha^{-1}	51.00 efg	4.22 fg	215.2 fgh	2.44 cde	13.3 cde	9.50 def	62.00 gh	53.74 h
Press mudd 10 t ha^{-1}	51.33 defg	4.33 efg	222.44 f	2.46 cde	13.2 de	10.16 cd	53.70 hi	42.43 hi
Press mudd 20 t ha^{-1}	53.00 cdef	4.11 fg	222.33 fg	2.51 cd	13.3 cde	10.66 c	68.73fg	54.00 h
Bio fertilizer F 5 t ha^{-1}	52.00 cdefg	3.44 h	210.00 h	2.42 e	13.4 cde	8.83 fg	45.33 i	34.24 i
Bio fertilizer 10 t ha^{-1}	50.66 fg	4.10 fg	217.00 fgh	2.46 cde	14.7 bcd	9.33 def	48.76 hi	39.01 i
25% less (168.75-84.0-126.0 NPK kg ha^{-1}) + FYM 10 t ha^{-1}	54.33 bcd	5.22 bcd	263.78 b	2.53 bc	14.77 bc	12.66 b	107.17 bc	105.80 bc
25% less (168.75-84.0-126.0 NPK kg ha^{-1}) + FYM 20 t ha^{-1}	58.33 a	5.83 b	266.78 b	2.63 a	16.99 a	13.33 ab	120.00 a	118.33 a
25% less (168.75-84.0-126.0 NPK kg ha^{-1}) + PM 10 t ha^{-1}	57.33 ab	5.83 b	267.00 b	2.61 ab	15.55 ab	12.66 b	106.30 bc	106.15 bc
25% less (168.75-84.0-126.0 NPK kg) + PM 20 t ha^{-1}	49.33 g	6.55 a	278.89 a	2.64 a	16.22 ab	14.00 a	123.66 a	119.60 a
25% less (168.75-84.0-126.0 NPK kg ha^{-1}) + BF 5 t ha^{-1}	54.00 cde	4.55 ef	250.00 d	2.44 cde	13.11 e	9.83 cdef	87.70 de	85.59 def
25% less (168.75-84.0-126.0 NPK kg ha^{-1}) + BF 10 t ha^{-1}	54.00 cde	4.88 cde	255.89 cd	2.45 cde	12.55 e	10.00 cde	90.60 de	88.11 fg
50% less (112.5-56.0-84.0 NPK kg ha^{-1}) + FYM 10 t ha^{-1}	50.66 fg	4.66 def	232.89 e	2.44 cde	12.99 e	9.33 def	80.50 ef	73.04 fg
50% less (112.5-56.0-84.0 NPK kg ha^{-1}) + FYM 20 t ha^{-1}	51.66 defg	4.88 cde	234.44 e	2.47 cde	13.66 cde	10.00 cde	82.60 e	76.00 efg
50% less 112.5-56.0-84.0 NPK kg + PM 10 t ha^{-1}	52.00 cdefg	5.22 bcd	235.00 e	2.47 cde	13.44 cde	9.500 def	84.00 de	74.33 fg
50% less (112.5-56.0-84.0 NPK kg ha^{-1}) + PM 20 t ha^{-1}	49.66 g	5.55 b	237.22 e	2.49 cde	13.33 cde	9.83 cdef	86.90 de	76.85 efg
50% less (112.5-56.0-84.0 NPK kg ha^{-1}) + BF 5 t ha^{-1}	52.00 cdefg	3.33 h	215.00 gh	2.48 cde	12.66 e	9.500 def	81.33 ef	70.15 g
50% less (112.5-56.0-84.0 NPK kg ha^{-1}) + BF 10 t ha^{-1}	51.33 defg	4.21 fg	214.89 h	2.44 cde	12.77 e	9.500 def	82.00 ef	72.30 g
S.E	1.6228	0.3167	3.6511	0.0466	0.7660	0.5308	6.687	6.164
LSD (0.5%)	3.2851	0.6412	7.3913	0.0943	1.5398	1.0745	13.539	12.479

PM= Press mud, FYM= Farm yard manure, B.F= Biofertilizer

Effect of inorganic and organic nutrients on physiological traits of plant crop: The results of the experiment showed that integrated use of FYM or press mud with in-organic fertilizers significantly recorded higher values of all the physiological traits of plant crop. The maximum leaf area plant^{-1} (5840 cm^2), leaf area index (10.51), crop growth rate (10.35 gm^{-2} day^{-1}) and dry matter (5542 gm^{-2}) were found with the application of three-fourth of recommended fertilizer (169-84-126)in combination of PM @ 20 t ha^{-1} and 5717 ,10.29 ,9.71 and 5206 respectively with the application of three-fourth of recommended fertilizer (169-84-126)in combination with FYM@ 20 t ha^{-1}.The mean values of these both treatments were statistically non-significant. However, under-dose applications of NPK fertilizer with organic sources significantly recorded less values of all the physiological traits of sugarcane plant crop.

The results of the study are also supported by Nasir *et al*., (2000) with opinion that higher growth rate of sugarcane was mainly due to the enhanced uptake of N, P and K. The minimum leaf area plant^{-1} (3076 cm^2), leaf area index (5.5), crop growth rate (6.13 gm^{-2} day^{-1}) and dry matter (3286 gm^{-2}) were noted in untreated plots (Table 2).

Table 2. Physiological parameters as influenced by organic and in organic plant nutrient management in sugarcane plant crop.

Treatments	Leaf area plant^{-1} (cm^2)	Leaf area index	Crop growth rate (gm^2 day^1)	Dry matter (gm^{-2})
Control (0-0-0)	3076 i	5.537 h	6.133 l	3286 k
Recommended (225-112-168)	5481 a	9.870 a	9.110 c	4880 c
FYM 10 t ha^{-1}	3270 hi	5.890 gh	6.327 kl	3390 jk
FYM 20 t ha^{-1}	3424 fghi	6.167 efgh	6.593 jk	3543 ijk
PM 10 t ha^{-1}	4478 bc	8.060 b	6.733 ij	3607 hijk
PM 20 t ha^{-1}	3632 efgh	6.540 defg	7.023 hi	3695 ghij
BF 5 t ha^{-1}	3360 ghi	6.050 fgh	6.217 kl	3331 k
BF 10 t ha^{-1}	3537 efgh	6.370 defg	6.563 jk	3516 ijk
Three-fourth of Recommended (169-84-126) + FYM 10 t ha^{-1}	5623 a	10.12 a	9.330 c	4999 bc
Three-fourth of Recommended (169-84-126) + FYM 20 t ha^{-1}	5717 a	10.29 a	9.717 b	5206 b
Three-fourth of Recommended (169-84-126) + PM 10 t ha^{-1}	5755 a	10.36 a	9.860 b	5282 ab
Three-fourth of Recommended (169-84-126) + PM 20 t ha^{-1}	5840 a	10.51 a	10.35 a	5542 a
Three-fourth of Recommended (169-84-126) + BF 5 t ha^{-1}	4460 bc	8.030 b	7.467 efg	4000 defg
Three-fourth of Recommended (169-84-126) + BF 10 t ha^{-1}	4573 b	8.230 b	7.897 d	4197 de
Half of Recommende.NPK (112-56.-84) + FYM 10 t ha^{-1}	3760 ef	6.770 def	7.263 fgh	3891 efgh
Half of Recommende.NPK (112.-56-84) + FYM 20 t ha^{-1}	3837 de	6.910 cde	7.453 efg	4292 d
Half of Recommende.NPK (112.-56-84) + PM 10 t ha^{-1}	4192 cd	7.550 bc	7.550 def	4035 def
Half of Recommende.NPK (112.-56-84) + PM 20 t ha^{-1}	3919 de	7.050 cd	7.690 de	4121 def
Half of Recommende.NPK (112.-56-84) + BF 5 t ha^{-1}	3715 efg	6.990 cd	7.113 gh	3810 fghi
Half of Recommende.NPK (112.-56-84)+ BF 10 t ha^{-1}	3813 e	6.860 cde	7.460 efg	3996 defg
S.E	120.4	0.2373	0.1238	101.5
LSD (5%)	344.4	0.6795	0.3545	290.6

Effect of inorganic and organic nutrients on qualitative traits of plant crop: The results of the experiment showed that application of three-fourth of the recommended NPK (169-84-126) + 20 t ha^{-1} press mud was superior nutrient level for obtaining maximum brix (23.56%), pol (20.07%), purity (85.18%) and commercial cane sugar (14.67%) and 23.36, 19.76, 84.56 and 14.37 respectively with application of three-fourth of the recommended NPK (169-84-126) + 20 t ha^{-1} FYM except fiber being higher (12.50%) in the unfertilized plots. The results are in agreement with the findings of Bokhtiar *et al.,* (2005) which reveals that press mud application with inorganic fertilizer increased brix, Pol and purity and thus showed better performance as compared to FYM or inorganic fertilizer alone .The minimum brix (20.76 %), pol (16.00 %), purity (77.04) and commercial cane sugar (10.86%) were recorded in control (Table 3).

Effect of inorganic and organic nutrients on NPK concentration and uptake of plant crop: The results of the study showed maximum concentration of N (1.55%), P (0.44%) and K (1.73%) having N uptake (165.94 kg ha^{-1}), P uptake (48.64 kg ha^{-1}) and K uptake (163.01 kg ha^{-1}) with the application of three-fourth of recommended NPK(169-84-126) plus press mud @ 20 t ha^{-1}and 1.54, 0.44, 1.21, 166.41, 47.77 and 130.18 respectively with the application of three-fourth of recommended NPK(169-84-126) with FYM @ 20 t ha^{-1}. These results are suported by Bokhtiar *et al*., (2001) that N, P and K was lower in sugarcane applied with inorganic fertilizers than the crop added with press mud. Efficient storage and recycling of animal manure could contribute to improved P utilization, which in turn may reduce P fertilizer requirements (Haygarth & Jarvis, 1999). However, minimum NPK concentration (1.16, 0.19 and 1.21% respectively) and NPK uptake (61.23, 10.46 and 64.67 kg ha^{-1} respectively) were observed in unfertilized plots (Table 4).

Table 3. Quality traits of sugarcane crop as influenced by organic and inorganic plant nutrients in sugarcane plant crop.

Treatments	Fiber (%)	Brix (%)	Pol (%)	Purity (%)	CCS (%)
Control (0-0-0)	12.50 a	20.76 q	16.00 r	77.04 mn	10.86 r
Recommended (225-112-168)	12.24 j	22.90 e	19.26 e	84.10 d	13.97 e
FYM 10 t ha^{-1}	12.38 ef	21.00 o	16.20 p	77.15 lm	11.02 p
FYM 20 t ha^{-1}	12.39 ef	21.16 m	16.35 o	77.27 klm	11.13 o
PM 10 t ha^{-1}	12.44 bc	21.36 l	16.53 n	77.37 kl	11.26 n
PM 20 t ha^{-1}	12.44 bc	21.66 k	16.79 m	77.51 k	11.46 m
BF 5 t ha^{-1}	12.44 bc	20.86 p	16.09 q	77.13 lm	10.94 q
BF 10 t ha^{-1}	12.40 cde	21.06 n	16.25 p	76.79 n	11.05 p
Three-fourth of Recommended (169-84-126) + FYM 10 t ha^{-1}	12.37 ef	23.16 d	19.56 d	84.45 c	14.21 d
Three-fourth of Recommended (169-84-126) + FYM 20 t ha^{-1}	12.33 gh	23.36 c	19.76 c	84.56 bc	14.37 c
Three-fourth of Recommended (169-84-126) + PM 10 t ha^{-1}	12.27 ij	23.46 b	19.91 b	84.86 ab	14.52 b
Three-fourth of Recommended (169-84-126) + PM 20 t ha^{-1}	12.25 j	23.56 a	20.07 a	85.18 a	14.67 a
Three-fourth of Recommended (169-84-126) + BF 5 t ha^{-1}	12.38 ef	22.76 f	18.94 g	83.20 e	13.62 g
Three-fourth of Recommended (169-84-126) + BF 10 t ha^{-1}	12.36 fg	22.86 e	19.06 f	83.37 e	13.73 f
Half of Recommende.NPK (112-56.-84) + FYM 10 t ha^{-1}	12.43 bcd	22.56 h	18.17 j	80.54 h	12.77 j
Half of Recommende.NPK (112.-56-84) + FYM 20 t ha^{-1}	12.44 bc	22.66 g	18.26 i	80.57 h	12.87 j
Half of Recommende.NPK (112.-56-84) + PM 10 t ha^{-1}	12.32 gh	22.76 f	18.73 h	82.29 g	13.37 i
Half of Recommende.NPK (112.-56-84) + PM 20 t ha^{-1}	12.29 hi	22.86 e	18.90 g	82.66 f	13.53 h
Half of Recommende.NPK (112.-56-84) + BF 5 t ha^{-1}	12.45 b	21.76 j	17.22 l	79.10 j	11.94 l
Half of Recommende.NPK (112.-56-84)+ BF 10 t ha^{-1}	12.40 de	22.03 i	17.52 k	79.52 i	12.19 k
S.E	0.0191	0.0186	0.0283	0.1595	0.0346
LSD (5%)	0.0387	0.0376	0.0572	0.3229	0.0700

Table 4. NPK concentration and uptake as influenced by inorganic and organic fertilizers in sugarcane plant crop.

Treatments	N (%)	P (%)	K (%)	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Control (0-0-0)	1.16 bj	0.44 ab	1.30 n	101.09 i	28.96 gh	84.8 2 k
Recommended (225-112-168)	1.44 ef	0.42 d	1.58 f	140.85 c	41.60 de	155.19 b
FYM 10 t ha^{-1}	1.51 b	0.42 d	1.46 h	102.23 i	28.52 gh	99.29 i
FYM 20 t ha^{-1}	1.54 a	0.41 d	1.66 b	104.32 hi	28.29 gh	112.90 g
PM 10 t ha^{-1}	1.42 g	0.42 d	1.48 g	100.21 i	29.99 gh	122.09 f
PM 20 t ha^{-1}	1.45 de	0.37 f	1.63 c	103.27 i	26.58 hi	116.09 g
BF 5 t ha^{-1}	1.34 i	0.40 e	1.61 d	88.76 j	26.62 hi	106.65 h
BF 10 t ha^{-1}	1.47 c	0.44 bc	1.39 k	98.95 i	29.59 gh	93.37 j
Three-fourth of Recommended (169-84-126) + FYM 10 t ha^{-1}	1.50 b	0.41 d	1.43 i	157.55 b	43.64 cd	149.54 c
Three-fourth of Recommended (169-84-126) + FYM 20 t ha^{-1}	1.54 a	0.44 ab	1.21 q	166.41 a	47.77 ab	130.18 e
Three-fourth of Recommended (169-84-126) + PM 10 t ha^{-1}	1.46 d	0.42 cd	1.41 j	153.97 b	45.17 bc	148.70 c
Three-fourth of Recommended (169-84-126) + PM 20 t ha^{-1}	1.55 a	0.44 ab	1.73 a	165.94 a	48.64 a	163.01 a
Three-fourth of Recommended (169-84-126) + BF 5 t ha^{-1}	1.42 g	0.42 d	1.49 g	130.06 d	38.86 ef	136.47 d
Three-fourth of Recommended (169-84-126) + BF 10 t ha^{-1}	1.43 ef	0.45 a	1.58 f	132.33 d	42.18 cde	145.53 c
Half of Recommende.NPK (112-56.-84) + FYM 10 t ha^{-1}	1.38 h	0.42 cd	1.60 e	114.60 fg	35.56 f	132.86 de
Half of Recommende.NPK (112.-56-84) + FYM 20 t ha^{-1}	1.43 fg	0.42 d	1.63 c	120.05 e	35.73 f	136.84 d
Half of Recommende.NPK (112.-56-84) + PM 10 t ha^{-1}	1.42 fg	0.33 g	1.38 l	126.97 d	29.81 gh	122.82 f
Half of Recommende.NPK (112.-56-84) + PM 20 t ha^{-1}	1.34 i	0.34 g	1.41 j	119.59 ef	30.73 g	125.84 f
Half of Recommende.NPK (112.-56-84) + BF 5 t ha^{-1}	1.22 j	0.33 g	1.37 m	91.68 j	24.82 i	102.96 hi
Half of Recommende.NPK (112.-56-84)+ BF 10 t ha^{-1}	1.43 ef	0.36 f	1.39 k	109.62 gh	27.84 ghi	106.06 h
S.E	7.574	7.556	4.806	2.6845	1.6861	2.0119
LSD (5%)	0.015	0.015	9.730	0.1382	0.0847	0.414

Economic analysis

Physical and revenue productivity: The partial economic analysis sugarcane plant crop showed maximum revenue of Rs. 299000 from cane yield sale (119.6) with application of press mud applied at 20 t ha^{-1}+ three-fourth of the recommended inorganic NPK fertilizer (169-84-126) followed by revenue of Rs. 295825 from cane yield sale (118.33 t ha^{-1}) with application of farm yard manure applied at 20 t ha^{-1} + three-fourth of the recommended inorganic NPK fertilizer (169-84-126) (Table 5).

Net returns: The high net returns of Rs. 187935 ha^{-1} were obtained with application of press mud applied at 20 t ha^{-1} + three-fourth of the recommended inorganic NPK fertilizer (169-84.-126.). However, Rs. 179760 were obtained with the application of farm yard manure applied @ 20 t ha^{-1} + three-fourth of the recommended inorganic NPK fertilizer (Table 5).

Cost benefit ratio: The cost benefit ratio 6.36 and 5.48 were higher in the treatment where press mud and farm yard manure applied at 20 t ha^{-1} + three-fourth of the recommended inorganic NPK fertilizer (169-84-126).

Table 5. Partial economic Analysis of organic and inorganic sugarcane plant crop.

Treatments	Physical productivity (t ha^{-1})	Revenue productivity (Rs)	Cost of production (Rs)	Net return (Rs)	Cost benefit ratio
Control (0-0-0)	30.4130.41 30.41	76025 76025	0	-	-
Recommended (225-112-168)	94.81	237025	33386	127614	4.82
Three-fourth of Recommended (169-84-126) + FYM 10 t ha^{-1}	105.8	264500	32540	155935	5.79
Three-fourth of Recommended (169-84-126) + FYM 20 t ha^{-1}	118.33	295825	40040	179760	5.48
Three-fourth of Recommended (169-84-126) + PM 10 t ha^{-1}	106.15	265375	30040	159310	6.3
Three-fourth of Recommended (169-84-126) + PM 20 t ha^{-1}	119.6	299000	35040	187935	6.36
Three-fourth of Recommended (169-84-126) + BF 5 t ha^{-1}	85.59	213975	35040	102910	3.93
Three-fourth of Recommended (169-84-126) + BF 10 t ha^{-1}	88.11	220275	45040	99210	3.2
Half of Recommende.NPK (112-56.-84) + FYM 10 t ha^{-1}	73.04	182600	24194	82381	4.4
Half of Recommende.NPK (112.-56-84) + FYM 20 t ha^{-1}	76	190000	31694	82281	3.59
Half of Recommende.NPK (112.-56-84) + PM 10 t ha^{-1}	74.33	185825	21694	79194	5.06
Half of Recommende.NPK (112.-56-84) + PM 20 t ha^{-1}	76.85	192125	26694	89406	4.34
Half of Recommende.NPK (112.-56-84) + BF 5 t ha^{-1}	70.15	175375	26694	72656	3.72
Half of Recommende.NPK (112.-56-84)+ BF 10 t ha^{-1}	72.3	180750	36694	68031	2.85

Cost of fertilizer: Urea Rs.14/kg,TSP Rs.40/kg and SOP Rs.50/kg.

Cost of Manures: Press mud Rs. 500/t,FYM Rs. 875/t and Biofertilizer Rs.4000/t

Cost of produce: Cane Rs.2500/t

Regression of cane yield as affected by various traits of sugarcane plant crop

Extent of relationship (r): Cane yield had positive relationship with millable cane 000 ha^{-1} (0.94) and (0.97), crop growth rate g m^{-2} day^{-1} (0.51) and (0.93) and commercial cane sugar percentage (0.52) and (0.78) under organic sources (A) and integrated plant nutrient treatments (B) respectively (Figs. 1, 2 & 3). These results are in agreements with the findings of Imtiaz *et al.,* (2012) that cane yield positively correlated with cane girth, weight per stool, sugar yield, tiller numbers and purity % whereas Pol % and CCS % showed negative correlation with cane yield. Sugar yield showed non significant correlation with cane girth.

Coefficient of determination (R^2): Cane yield of plant crop showed variation due to its coalition with millable cane 000 ha^{-1} (0.94%) and (0.97%), crop growth rate g m^{-2} day^{-1} (0.51%) and (0.93%) and commercial cane sugar (0.52%) and (0.78%) under organic sources (A) and integrated plant nutrient treatments (B) respectively (Figs. 1, 2 & 3).

Regression coefficient (b): Unit increase in different plant traits viz., millable cane (0.89) and (1.17), crop growth rate g m^{-2} day^{-1} (19.91) and (15.19) and commercial cane sugar percentage (30.47) and (18.43) under organic sources (A) and integrated plant nutrient treatments (B) respectively (Figs. 1, 2 & 3).

Student T value: Significant student T value were obtained for millable can 000 ha^{-1} (13.53), crop growth rate g m^{-2} day^{-1} (0.1238) and commercial cane sugar percentage (0.0700).

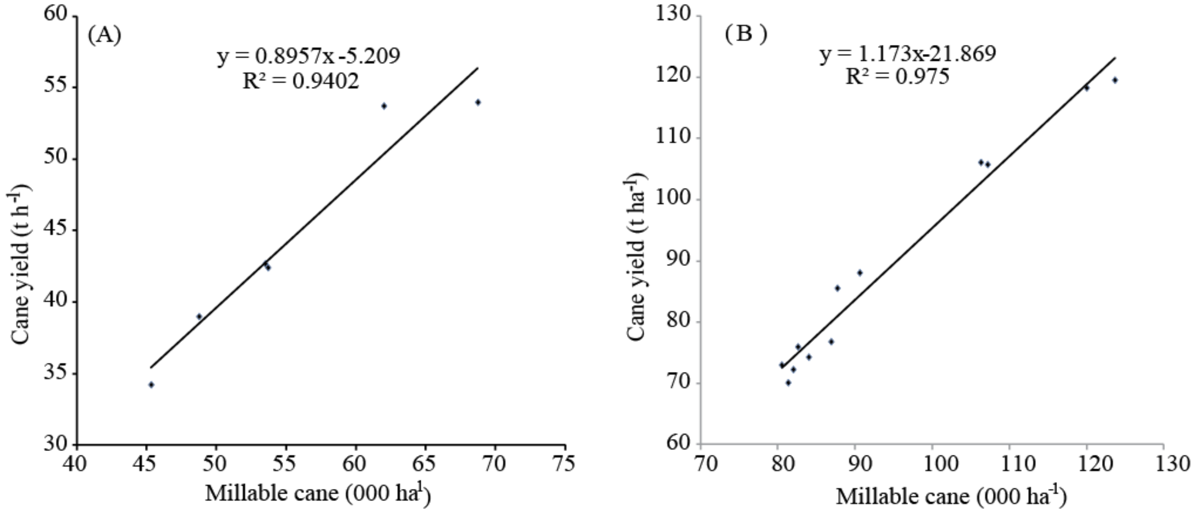

Fig. 1. Relationship between millable cane and cane yield of sugarcane plant crop under organic (A) and integrated nutrition (B).

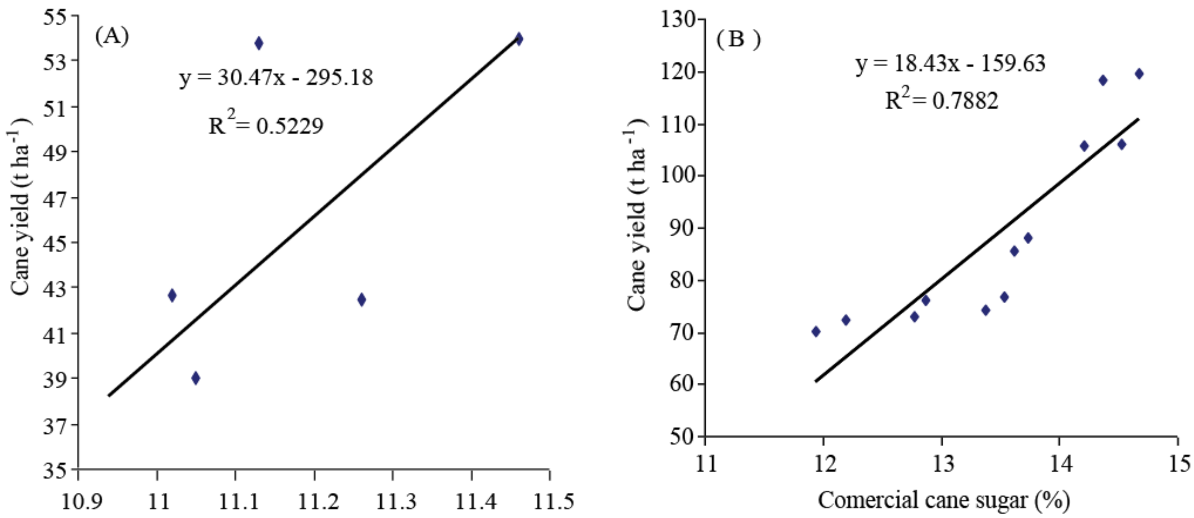

Fig. 2. Relationship between commercial cane sugar and cane yield of sugarcane plant crop under organic (A) and integrated nutrition (B).

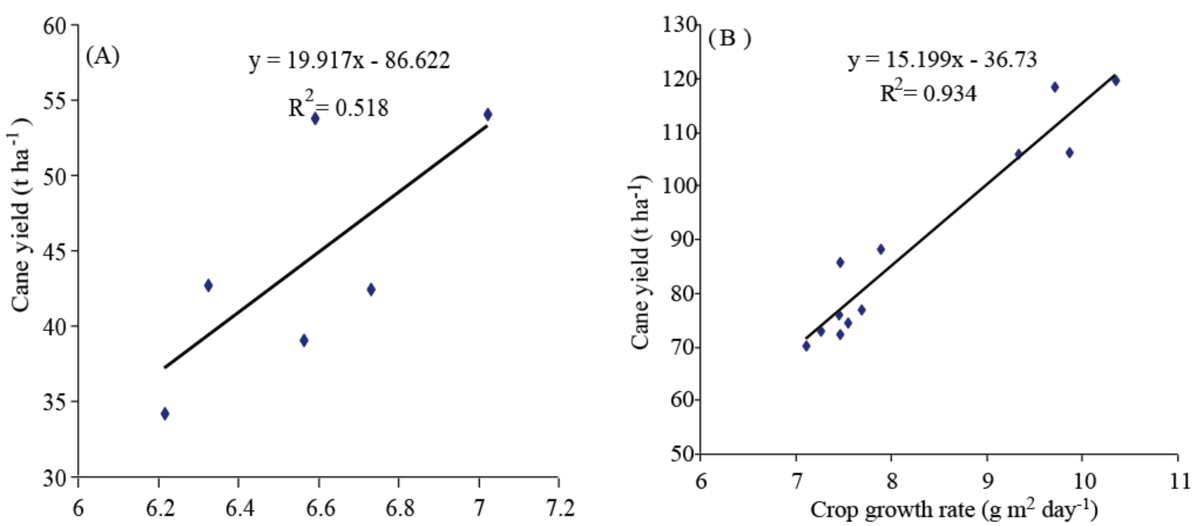

Fig. 3. Relationship between crop growth rate and cane yield of sugarcane plant crop under organic (A) and integrated nutrition (B).

Conclusion

It is concluded that integrated nutrient management recorded 25% saving of inorganic fertilizers due to application of FYM and or press mud applied at 20 t $ha^{-1.}$

Partial economic analysis showed higher revenue and net returns through integration of organic and inorganic nutrient sources. Integration of organic and inorganic nutrients should be practiced. This will not only enhance growth, yield, quality and nutrient uptake of sugarcane but also conserve agro-ecosystem for sustainable crop production.

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