ISSN 2229-5518

Effect of Supplemental Inorganic NPK and Residual Organic Nutrients on Sugarcane Ratoon Crop

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Abstract- This study was conducted to evaluate the effect of supplemental dose of inorganic NPK fertilizers with residual organic fertilizers on the yield and quality of sugarcane at Agriculture Research Institute, Tandojam, Pakistan, (25^{o}25'60'N 68^{o}31' 60E). Sugarcane variety Thatta-10 was planted and following treatments were arranged in RCBD: Control (0-0-0), recommended dose (225-112-168) , 10 & 20 tons residual FYM & Press mud,5 & 10 tons residual bio fertilizer , three-fourth of recommended rate (169-84-126) , half of recommended rate(112-56-84) were applied on residual 10 & 20 tons FYM & Press mud and 5 & 10 tons of bio fertilizer plots. Maximum tillers plant^{-1}, plant height, stem girth, internodes plant^{-1}, internodes length, millable canes, cane yield, leaf area plant^{-1}, leaf area index, crop growth rate, dry matter, brix, pol, purity, commercial cane sugar, NPK uptake and accumulation under residual impact of press mud and or FYM at 20 t ha^{-1} + supplemental application of three-fourth of recommended rate of NPK fertilizer (169-84-126).The residual effect of FYM and press mud showed significant effect on subsequent ratoon crop. Residual FYM and or press mud at 20 t ha^{-1} + supplemental application of three-fourth of recommended rate of NPK fertilizer (169-84-126) was found sufficient nutrient levels. The applications of FYM, press mud and biofertilizers without inorganic NPK fertilizers were found less efficient. It is concluded that integrated nutrient management recorded 25% saving in inorganic fertilizers with 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.

Index Terms*:* **Sugarcane, Pressmud, FYM, Biofertilizer, residual effect, Yield, Quality& Uptake.**

Introduction

There is increased emphasis on the impact on environmental quality due to continuous use of chemical fertilizers. The integrated nutrient management system or conjunctive use of different nutrient sources is an alternative and is characterized by reduced input of chemical fertilizers and combined use of chemical fertilizers with organic materials such as animal manures, crop residues, green manure and composts. The residual nutrients from cattle dung combined with inorganic fertilizer (N, P & K) became necessary to be supplemented with inorganic fertilizer at the half of the recommended rate 60-13-19 NPK kg ha^{-1} as sugarcane being a long duration crop and also higher feeder.

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The residual from the separate application of cattle dung and inorganic fertilizer alone cannot sustain the production of sugarcane [7].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.

When organic fertilizers are used repeatedly, residual effects accumulate and significantly increase the availability of N [37], [36], [27], [28]. Farmers are aware of this soil pool and rightly feel that the outcomes of short-term field experiments, used to persuade them to cut N rates, ignore the long-term consequences of reduced N inputs [20]. The released nitrogen (N) from the mineralization process has a fertilizing effect on the arable crops that follow [4], [22].

Farm yard manure is often recommended for improving land productivity for better crops yield. [6].suggested that to obtain potential yields, 50% of total N requirements should be made available in the form of FYM and 50% applied in the form of fertilizers. This combination gave higher yield of cane than application of either the manure or fertilizer alone. In sugarcane based cropping system, the residual effect of fertilizer and decomposition of crop residues is of great consideration. The superiority of FYM over the inorganic fertilizers (NPK) is due to more favourable effect of former on soil aggregation resulting into better physical condition of the soil [25]. The FYM alone and with NPK fertilizer considerably improved the water holding capacity of soil, while the continuous application of Ammonium sulphate decreased the water holding capacity [32]. High pH soils are known to pose problem of P fixation thus reducing nutrient availability to plants. Farmyard manure is known to improve cation exchange capacity of soils, which has a direct bearing on the availability of nutrients. Application of inorganic fertilizer to soils, after thorough mixing with well rotten FYM, has been found to reduce the fixation of applied phosphorus and enhances crop yields [31], [2]. It was observed that FYM mobilizes other nutrients especially P for better uptake by plant. Combined application of cow-dung at 20 and 10 t ha^{-1} with 50 kg N ha $^{-1}$ increased yield production of successive cane cropping [40].Cattle manure is not readily decomposable and its annual decomposition rate has been reported to be in the range of 10-20% [9], [19] , [23]. On the decomposition of cattle manure in an upland field with sandy soil in Khon Kaen, Northeast Thailand, the decomposition rate of cattle manure over a period of 5 months was approximately 20% [18]. It is considered that this low decomposability of cattle manure leads to an increase in SOC stock, even in tropical zones.

Material and Methods

The experiment was conducted at Sugarcane Section of Agriculture Research Institute, Tandojam, Pakistan, located at 25^0 25.19 N 68^0 32.07 E. Soil was clay loam in texture, (EC 0.14 to 0.68 dS m^{-1}), slightly alkaline in reaction (pH 7.25 to 7.76), calcareous ($CaCO_3$ 9.5%), low to adequate in organic matter (0.64 -1.01%), total nitrogen content varies from 0.03 – 0.06%) and available phosphorus ranged from 6.8 to 17.0 mg kg^{-1}, however, soil under study was marginal to high in ammonium acetate extractable potassium and ranged from 110 - 220 mg kg^{-1}. The Experiment was conducted by using the randomized complete block design, the net plot size 35m^2 was kept and all the treatments were replicated three times, sugarcane variety Thatta-10 was tested with residual organic and supplemental application of NPK fertilizer levels viz Control (0-0-0), recommended dose (225-112-168) , 10 & 20 tons residual FYM & Press mud ,5 & 10 tons residual bio fertilizer ,three-fourth of recommended rate (169-84-126) & half of the recommended (112-56-84) supplemental NPK doses were applied in residual 10 & 20 tons FYM & Press mud and 5 & 10 tons of bio fertilizer plots.

Cultural Practices

After harvesting of sugarcane plant crop, the underground parts of the plants were allowed to remain in the soil and give rise to ratoon crop for evaluating the residual effect of organic manures. Timely stubble shaving and inter-row cultivation were carried to straighten the rows. Proper cultural practices and efficient crop management was adopted to improve ratoon growth. Irrigation water was applied according crop requirements. However, the frequency of irrigations in winter months was lower (15 days interval) as compared to summer months (8-10 days interval). Overall, twenty five irrigations were applied during the growing season. Supplemental NPK 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 split applied in three equal doses i.e. during 1st, 4th irrigation and completion of tillering, whereas, all phosphorus and potash were applied after stubble shaving. No fresh farmyard manure or pressmud were applied to examine the residual effects. Earthingup was practiced twice in ratoon crop. The weeds were controlled through interculturing. Stem borers were controlled through release of *Trichogramma chilonis* (Lshii). Larsben was applied at the rate of 5 lit ha^{-1} with 1st 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 [10].

Agronomic Observations

The plant data recorded from the experiment was related to: Plant height (cm), tillers plant^{-1}, internodes plant^{-1}, stem girth (cm), millable canes (000) ha^{-1} and cane yield t ha^{-1}at the time of harvesting.

Physiological Observations

Physiological observations viz: Leaf area (cm^2), leaf area index, crop growth rate (gm^2 day$^{-1)}$ and dry matter (gm^{-2}) were recorded from the experiment during the study.

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 and 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 supplemental inorganic NPK and residual organic nutrient sources on agronomic traits of sugarcane ratoon crop.

The results of the experiment revealed maximum tillers plant^{-1} (6.9), plant height (222.7 cm), stem girth (2.56 cm), internodes plant^{-1} (23.3), internode length (13.50 cm), millable canes (121.33 thousands ha^{-1}) and cane yield (119.66) of ratoon crop with the residual effect of FYM @ 20 t ha^{-1} and application of supplemental three-fourth of recommended NPK (169-84.-126) and 6.6, 226.4 , 2.48 , 25.1 ,12.8 , 122.0 and 121.33 respectively with residual effect of press mud @ 20 t ha^{-1} plus supplemental three-fourth of recommended NPK (169-84.-126 kg ha^{-1}). The mean values of both the treatments were statistically non-significant. The findings of [34], supported the results of this study and revealed that the organic fertilizers increased the organic C and ultimately cane yield. The minimium values for tillers plant^{-1} (4.4), plant height (154.6 cm), stem girth (2.28 cm), internodes plant^{-1} (15.0), internode length (8.1 cm), millable canes (42.0 thousands ha^{-1}) and cane yield (30.66) were observed for the control.(Table 1)

The reason behind increased values in all the sugarcane ratoon traits was due to decomposition of manures. It is reported that organic fertilizer has residual effect after the year of its application to land, as the decomposition of organic material usually takes more than a season [16], [17]. Consequently, mineralization generally extends over a much longer period than just one year. Manures therefore have a residual effect on crop as well as soil fertility [16] , [17] , [36], [27], [29] . The increase in sugarcane traits with the integrated use of organic and inorganic nutrient sources might be efficiency of these nutrient sources to increase microbial activity, soil porosity, water holding capacity and nutrient uptake efficiency of crop which ultimately enhanced quantitative as well as qualitative traits of sugarcane crop.

Effect of supplemental inorganic NPK and residual organic nutrients sources on physiological traits of sugarcane ratoon crop

In ratoon sugarcane, the leaf area plant^{-1} (5974 cm^2) and leaf area index (10.75), crop growth rate (10.20 gm^{-2} day^{-1}) and dry matter (5466 gm^{-2}) were found due to the residual effect of FYM @20 t ha^{-1} plus supplemental three-fourths of inorganic NPK fertilizer (169-84-126) and 6103, 10.99 , 10.86 and 5819 respectively with press mud applied @ 20 t ha-^{1} plus supplemental three-fourth of inorganic NPK fertilizer (169-84-126) which was higher than the previously described treatment but statistically the mean difference was non-significant.. The minimum leaf area plant^{-1} (3000 cm^2), leaf area index (5.40), crop growth rate (5.97 gm^{-2} day^{-1}) and dry matter (3202 gm^{-2}) were noted in control plots where no fertilizer was applied (Table 2).

Effect of supplemental inorganic NPK and residual organic nutrient sources on quality traits of sugarcane ratoon crop

The results for the qualitative traits of sugarcane ratoon crop showed maximum brix (23.70 %), pol (20.21 %), purity (85.27 %) and commercial cane sugar (14.78 %) with the application of supplemental three-fourth of the recommended NPK fertilizer (169-84-126) + residual press mud @20 t ha^{-1} followed by 23.46,19.89,84.78,and 14.49 respectively with the application of supplemental three-fourth of the recommended NPK fertilizer (169-84-126) + residual FYM @20 t ha^{-1} Whereas, higher fiber (12.42/12.36 %) was recorded in the unfertilized crop or in the plot where biofertilizer was applied. The results are in agreement with the findings of [38], Sugarcane ratoons have an additional advantage of better juice quality and sugar recovery in comparison to plant crop of same variety under similar conditions. Organic manures applied to the crop markedly enhanced the ratoon cane yield and juice quality [32].

The minimum brix (20.86 %), pol (16.09 %), purity (75.14) and commercial cane sugar (10.93 %) were recorded in control treatments (Table 3).

Effect of supplemental inorganic NPK and residual organic nutrient sources on NPK concentration and uptake of sugarcane ratoon crop

The results for the NPK concentration and uptake of sugarcane ratoon crop showed maximum concentration of N (1.35 %), P (0.37 %) and K (1.59 %) with N uptake (150.14 kg ha^{-1}), P uptake (40.94 kg ha^{-1}) and K uptake (168.95 kg ha^{-1}) in the foliage with the supplemental application of three-fourth of recommended NPK fertilizer at (169-84-126) + 20 t ha^{-1} press mud followed by 1.35, 0.37, 1.39, 143.31.,40.93 and 51.36 respectively with the supplemental application of three-fourth of recommended NPK fertilizer at (169-84-126) + 20 t ha^{-1} FYM. Soil N, P and K contents after the end of the cropping cycle increased when NPK was applied with organic fertilizers because separate application of manure and inorganic fertilizer alone cannot sustain the production of sugarcane. [15].In the Support of this study [24] reported that sugarcane treatments with organic and inorganic fertilizers significantly produced higher ratoon cane yield over recommended fertilizers and control. Whereas, the minimum leaf NPK concentration of 1.08, 0.20 and 1.17 % and NPK uptake of 72.26, 13.78 and 78.22 kg ha^{-1} respectively were observed in control plots (Table 4).

Economic Analysis

Physical and revenue productivity

The partial economic analysis sugarcane ratoon crop showed maximum revenue of Rs. 303325 from cane yield sale (121.33) with application of press mud (residual) applied at 20 t ha^{-1} + supplemental application of three-fourth inorganic NPK fertilizer (169-84-126) follwed by revenue of Rs. 299150 from cane yield sale (119.66 t ha^{-1}) with application of farm yard manure (residual) applied at 20 t ha^{-1} + supplemental application of three-fourth inorganic NPK fertilizer (169-84-126) (Table 5).

Net returns

The high net returns of Rs. 201635 ha^{-1} were obtained with application of press mud (residual) applied at 20 t ha^{-1} + supplemental application of three-fourth inorganic NPK fertilizer (169-84.-126.). However, Rs. 197460 were obtained with the application of farm yard manure (residual) applied @ 20 t ha^{-1} + supplemental application of three-fourth inorganic NPK fertilizer (Table 5).

Cost benefit ratio

The cost benefit ratio 9.05 and 8.88 were higher in the treatment where press mud and farm yard manure (residual) applied at 20 t ha^{-1} + supplemental application of three-fourth of inorganic NPK fertilizer (169-84- 126)

Correlation coefficient and regression analysis of various sugarcane traits with cane yield of ratoon crop as influenced by application of inorganic NPK and residual organic nutrient sources.

Correlation coeficient (r)

Correlation analysis showed that cane yield had a positive relationship with millable cane 000 ha^{-1} (0.98), crop growth rate gm^{-2} day^{-1} (0.94) and commercial cane sugar percentage (0.95) which was statically highly significant.

Coefficient of determination (R^2)

Cane yield of plant crop showed variation due to its coalition with millable cane 000 ha^{-1} (0.98%), crop growth rate gm^{-2} day^{-1} (0.89%) and commercial cane sugar (0.92 %).

Regression coefficient (b)

The regression analysis clearly indicates that unit increase in sugarcane yield is influenced by sugarcane traits viz millable cane (0.89), crop growth rate gm^{-2} day^{-} (0.04) and commercial cane sugar percentage (0.04).

Student T value

Significant student T value was obtained for millable can 000 ha^{-1} (12.66), crop growth rate gm^{-2} day^{-1} (0.1304) and commercial cane sugar percentage (0.0756).

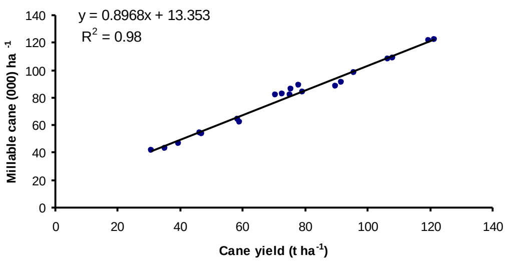

Figure-1. Correlation & Regression of millable cane on cane yield of ratoon crop -

as influenced supplemental inorganic NPK and residual organic nutrient sources .

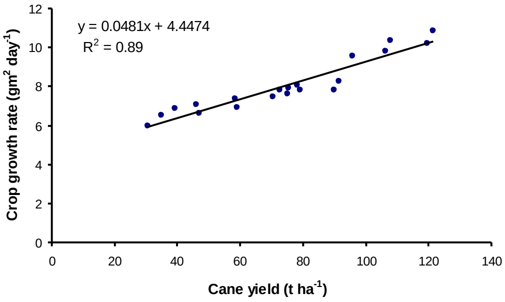

Figure-2.Correlation & Regression of crop growth rate on cane yield of ratoon crop influenced supplemental inorganic NPK & residual organic nutrient sources

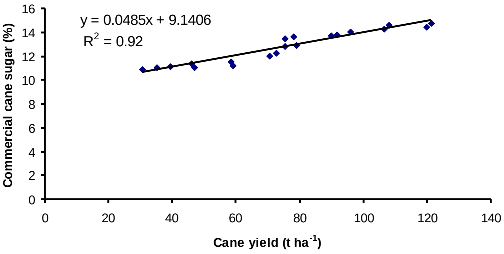

Figure-3.Correlation & Regression of commercial cane sugar on cane yield of ratoon crop influenced by supplemental inorganic NPK and residual organic nutrient sources

Conclusions

Integrated nutrient management recorded 25% saving in inorganic fertilizers due to application of FYM and or press mud applied at 20 t ha^{-1}.The residual effect of FYM and press mud showed significant effect on subsequent ratoon crop. The residual application of FYM and or press mud at 20 t ha^{-1} + supplemental application three-fourth of recommended rate NPK fertilizer (169-84-126 kg ha^{-1}) was found sufficient and economic nutrient level. 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.

LITERATURE CITED

[1] Bevacqua, R. F. and V. J. Mellano (1994). Cumulative effects of sludge compost on crop yields and soil properties. Commun. Soil. Sci. Plant Anal. 25: pp. 395.

[2] Choudhary, T. M. and S. M. Qureshi (1980). 50 years rench in gri.Chemistry- A review, Agri. Res. Institute, Tandojam. pp. 39-41

[3] DeLuca, T. H. and D. K. DeLuca (1987). Composting for feedlot manure management and soi quality. J. Prod. Agric. 10:236-241.

[4] Eriksen, J. (2001). Nitrate leaching and growth of cereal crops following cultivation of contrasting temporary grasslands. J. Agricultural Sci. Cambridge. 136, 271–281.

[5] Eriksen, J., F. P. Vinther and K.Soegaard (2004). Nitrate leaching and N2 .xation in grasslands of different composition,age and manag. J. Agri. Sci.

[6]Fasihi, S. D and K. B. Malik (1989).Fifty years of sugarcane research (1935-85) at sugarcaneres.Instt.Faisalabad.Directorate of Agri. Infrormation, Govt. of Punjab, Lahore. 142: 141–151.

[7]Gana, A.K ,2009.Evaluation of the residual effect of cattle manure combinations with inorganic fertilizer and chemical weed control on the sustainability of chewing sugarcane production at Badeggi Southern Guinea Savanna of Nigeria.ME J Scientific Research ,4 (4): 282-287.

[8] Gana, A. K. and L. D. Busari (2006). Contribution of green and farm yard manure nitrogen nutrition of sugarcane.Sugar Tech. 2/3: 175-179

[9] Gerzabek, M. H., F. Pichlmayer, H. Kirchmann and G. Haberhauer (1997). The response of soil organic matter to manure amendments in a long-term experiment at Ultuna, Sweden. Eur. J.Soil Sci. 48: 273-282.

[10] Gomez, K. A. and A. A. Gomez (1984). Statistical Procedure for Agricultural Research, (2 eds.), Wiley, New York, USA. pp. 680.

[11] Hallmark, W. B., S. E. Feagley, G. A. Breitenbeck, L. P. Brown, X. Wan and G. L. Hawkins (1995).Use of composted municipal waste in sugarcane production. Louisiana Agric. 38:15-16.

[12] Henpithaksa, C. (1993). Effect of organic matter on growth and yield of elephant foot yam *(Amorphophallus oncophyl-lus).* Kasetsart J. Nat. Sci. 27: 255-260.

[13] Hoitink, H. A. J., and P.C. Fahy (1986). Basis for the control of soil borne plant pathogens with composts. Annu. Rev. Phytopathol. 24:93-114.

[14] Kumar, M. D., K. S. Channabasappa and S. G. Patil (1996). Effect of integrated application of pressmud and paddy husk with fertilizers on yield and quality of sugarcane (*Saccharum officinarum*). Indian J. Agrono. 41 (2): 301-305.

[15]Lakshikantham, M. (1983). Technology in sugarcane Growing. Andhra Pradesh Agri. Univ., Hyd. Second Edn., pp. 259.

[16] Lund, Z.F. and B. D. Doss (1980). Residual effects of dairy cattle manure on plant growth and soil properties. Agron. J. 72:123–130.

[17] Magdoff, F. R. and J. F. Amadon (1980). Yield trends and soil chemical changes resulting from N and manure application to continuous corn. Agron. J. 72: 161–164.

[18] Matsumoto, N. P. and V. Treloges(1999). Nitrogen cycles on agricultural practices in Khon Kaen province. *In* M. Suzuki and S. Ando (eds.) Highlight of Collaborative Research Activities between Thai Research Organizations and JIRCAS, JIRCAS Thailand Office, Bangkok. pp. 32-33.

[19] Miyittah, M. and K. Inubushi (2003). Decomposition and CO_2-C evolution of okara, sewage sludge, cow and poultry manure composts in soils. Soil Sci. Plant Nutr. 49: 61-68.

[20]Motavalli, P. P., L. G. Bundy, T. W. Andraski and A. E. Peterson (1992). Residual effects of long-term fertilization on nitrogen availability to corn. J. Produ. Agric. 5:363–68.

[21] Nagaraju, M. S., C. Shankaraiah and U. Ravindra (2000). Effect of integrated use of fertilizer nitrogen with sulphitation pressmud and Azotobacter on growth, yield and quality of sugarcane. Mysore J. Agri. Sci. 34 (4): 311-316 .

[22] Nevens, F. and D. Reheul (2002). Thenitrogen and non-nitrogen contribution effect of ploughed leys on the following arable forage crops: determination and optimum use. Eur. J. Agron. 16: 57-74.

[23] Nyamangara, J. M. I. Piha and H. Kirchmann (1999). Interactions of aerobically decomposed cattle manure and nitrogen fertilizer applied to soil. Nutr. Cyc. Agroecosyst. 54: 183-188.

[24] Paul, G. C., M. H. Rahman and A. B. M. M. Rahman (2005). Integrated nutrient management with organic and inorganic fertilizers on productivity of sugarcane ratoon in Bangladesh Sugar Tech.7 (2/3): 20-23

[25] Rebindra, B., G. V. Narayanaswamy, N. A. Janardhan Gowda, and Shivana Gappa (1985). Long range effect of manures and fertilizer on soil physical properties and yield of sugarcane. J. Ind. Soc. Soil Sci. 33: 704-706.

[26] Reijntjes, C., B. Haverkort, and A. Waters-Bayer (1992). Farming for the future: An introduction to low external input and sustainable agriculture.London: Macmillan Press Ltd.

[27] Schroder, J .J. and H. V. Keulen (1997). Modelling the residual N effect of slurry applied to maize land on dairy farms in The Netherlands. Neth. J. Agric. Sci. 45: 477-494.

[28] Schroder, J. J. (2005). Revisiting the agronomic benefits of manure: a correct assessment and exploitation of its fertilizer value spares the environment. Bio resource Tech. 96 (2): 253-261.

[29] Schroder, J. J., L. T. Holte and G. Brouwer (1997). Effects of slurry placement on silage maize yields. Neth. J. Agric. Sci. 45: 249-261.

[30] Sekhon, G. S. and O. P. Meelu (1994). Organic matter management in relation to crop production in stressed rainfed systems. In Stressed ecosystems and sust. Agric. ed. S.

[31]Sharif, M., M. Faquir and A. Munir (1966). Effect of salts on 'P' uptake. Nucleus, 3 (2): 32-34.

[32] Singh, I. S., R. Singh, M. P. Yadav, R. R. Singh and S. B. Singh (2003). Ratooning behaviour of new promising varieties of sugarcane under Bhat soil conditions. Indian Sugar. LIII (5): 333-336.

[33] Tate, K. R. (1985). Soil phosphorus. In:Vaughan, D. and Malcolm, R. E. Soil Organic Matter and Biological Activity. Nijhof-Junk, Dordtrecht. 329-377.

[34] Vijay, K. and K. S. Verma (2002). In Influence of use of organic manure in combination with inorganic fertilizers on sugarcane and soil fertility. Idian Sugar, 52 (3): 177-181.

[35] Whitehead, D. C., A.W. Bristow, and D. R. Lockyer (1990). Organic matter and nitrogen in the unharvested fractions of grass swards in relation to the potential for nitrate leaching after ploughing Plant and Soil. 123: 39–49.

[36] Whitmore A. P. and J. J. Schroder (1996). Modelling the change in soil organic C and N in response to applications of slurry manure. Plant and Soil. 184: 185–194.

[37] Wolf, J. D., C. T. Wit and V. H. Keulen (1989). Modeling long-term crop response to fertilizer and soil nitrogen. I. The model. Plant Soil. 120: 11–22.

[38] Yadav, R. L. (1985). Peri Ganne Main Urvarak Parbandh. Khad Patrika. 26 (5): 25-28.

[39] Yadav, R. L. (1994). Agronomy of sugarcane: Principle and Practice. Ist Eds. International Book Distributing Co. Lucknow, India.

[40] Yadev, R.L. and S.K. Prasad, 1992. Conserving the organic matter content of the soil to sustain sugarcane yield and uptake by sugarcane. Bharatiya sugar, 18

Table 1. Effect of supplemental inorganic NPK & residual organic nutrients on sugarcane ratoon crop.

Treatments	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 (0-0-0)	4.4 fghi	154.6 h	2.28 ab	15.0 j	8.1 g	42.00 i	30.66 k
Recommended (225-112-168)	6.3 ab	203.8 abcd	2.55 ab	23.7 b	12.8 ab	98.00 cd	95.73 cd
Residual FYM 10 t ha^{-1}	4.8 defg	164.8 gh	2.42 ab	17.0 hi	9.1 fg	54.00 fg	46.90 ij
Residual FYM 20 t ha^{-1}	5.8 bc	170.5 fgh	2.45 ab	18.2 fg	9.0 fg	62.50 f	59.11 ghi
Residual PM 10 t ha^{-1}	4.9 defg	181.3 defg	2.41 ab	18.1 fg	9.3 fg	54.20 fg	46.11 ij
Residual PM 20 t ha^{-1}	5.3 cde	181.2 defg	2.53 ab	18.7 ef	10.0 ef	64.00 f	58.32 hi
Residual BF 5 t ha^{-1}	3.7 l	165.0 gh	2.35 ab	16.0 j	8.6 fg	43.00 g	35.00 jk
Residual BF 10 t ha^{-1}	4.6 efgh	170.2 fgh	2.36 ab	16.3 ij	9.0 fg	47.00 g	39.33 jk
Residual FYM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	6.5 ab	213.4 abc	2.75 a	23.0 b	13.0 ab	108.50 c	106.33bc
Residual FYM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	6.9 a	222.7 ab	2.56 ab	23.3 b	13.50 a	121.33 a	119.66 a
Residual PM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	6.4 ab	202.0 bcd	2.73 ab	23.4 b	12.8 abc	109.00 bc	108.00 bc
Residual PM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	6.6 a	226.4 a	2.48 ab	25.1 a	12.8 abc	122.00 a	121.33 a
Residual BF 5 t ha^{-1} + Three-fourth of Recommended (169-84-126)	4.8 defg	190.3 cdef	2.63 ab	19.5 de	9.3 fg	88.30 de	89.86 de
Residual BF 10 t ha- ^{1} + Three-fourth of Recommended (169-84-126)	5.4 cd	202.3 bcd	2.40 ab	19.8 d	10.0 ef	91.30 de	91.51 de
Residual FYM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	5.1 def	188.6 defg	2.37 ab	20.0 cd	9.8 ef	82.00 e	75.23 de
Residual FYM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	5.5 cd	182.6 defg	2.36 ab	20.7 c	9.8 ef	84.00 e	79.04 f
Residual PM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	5.5 cd	197.2 cde	2.55 ab	19.4 de	10.8 de	86.00 de	75.44 ef
Residual PM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	5.8 bc	178.0 efgh	2.55 ab	19.4 de	11.5 cd	89.00 de	78.07 f
Residual BF 5 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	4.2 ghi	176.4 efgh	1.99 b	17.5 gh	9.66ef	82.00 e	70.33 ef
Residual BF 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	3.9 hi	191.2 cdef	2.50 ab	18.5 f	9.66f	82.80 e	72.50 fgh
S.E	0.3649	11.824	0.1940	0.42	0.67	6.816	6.255 fg
LSD (0.5%)	0.7388	23.937	0.7367	0.87	1.36	13.799	12.664

Table 2. Effect of supplemental inorganic NPK and residual organic nutrients sources on physiological traits of sugarcane ratoon crop.

Treatments	Leaf Area plant^{-1} (cm^2)	Leaf Area Index	CGR g m^2 day^{-1}	Dry matter g m^{-2}
Control (0-0-0)	3000 i	5.400 i	5.977 l	3202 l
Recommended (225-112-168)	5728 a	10.31a	9.563 c	5124 c
Residual FYM 10 t ha^{-1}	3417 h	6.150 h	6.643 k	3560 k
Residual FYM 20 t ha^{-1}	3558 fgh	6.440 fgh	6.923 jk	3710 jk
Residual PM 10 t ha^{-1}	4680 bc	8.423 bc	7.070 ij	3787 ij
Residual PM 20 t ha^{-1}	3795 efgh	6.833 efgh	7.373 hi	3950 hi
Residual BF 5 t ha^{-1}	3511 gh	6.320 gh	6.527 k	3498 k
Residual BF 10 t ha^{-1}	3696 efgh	6.650 efgh	6.893 jk	3692 jk
Residual FYM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	5876 a	10.58 a	9.797 c	5249 c
Residual FYM 20 t ha^{-1} +Three-fourth of Recommended (169-84-126)	5974 a	10.75 a	10.20 b	5466 b
Residual PM 10 t ha^{-1} +Three-fourth of Recommended (169-84-126)	6014 a	10.83 a	10.35 b	5546 b
Residual PM 20 t ha^{-1} +Three-fourth of Recommended (169-84-126)	6103 a	10.99 a	10.86 a	5819 a
Residual BF 5 t ha^{-1} +Three-fourth of Recommended (169-84-126)	4661 bc	8.387 bc	7.840 efg	4200 efg
Residual BF 10 t ha^{1} +Three-fourth of Recommended (169-84-126)	4779 b	8.603 b	8.290 d	4442 d
Residual FYM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	3929 ef	7.073 ef	7.627 fgh	4086 fgh
Residual FYM 20 t ha^{-1} +Half of Recommende.NPK (112-56.-84)	4010 de	7.217 de	7.823 efg	4192 efg
Residual PM 10 t ha^{-1} +Half of Recommende.NPK (112-56.-84)	4381 cd	7.883 cd	7.927 def	4247 def
Residual PM 20 t ha^{-1} +Half of Recommende.NPK (112-56.-84)	4095 de	7.370 de	8.077 de	4326 de
Residual BF 5 t ha^{-1} +Half of Recommende.NPK (112-56.-84)	3882 efg	6.987 efg	7.467 gh	4001 gh
Residual BF 10 t ha^{-1} +Half of Recommende.NPK (112-56.-84)	3984 e	7.173 e	7.833 efg	4196 efg
S.E	126.1	0.2251	0.1304	69.73

LSD (5%)	361.0	0.6444	0.3733	199.6

Table3. Effect of supplemental inorganic NPK and residual organic nutrient sources on quality traits of sugarcane ratoon crop.

Treatments	Fiber (%)	Brix (%)	Pol (%)	Purity (%)	CCS (%)
Control (0-0-0)	12.42 a	20.86 m	16.09 r	75.14 g	10.93 r
Recommended (225-112-168)	12.22 h	23.00 d	19.37 e	84.22abcd	14.05 e
Residual FYM 10 t ha^{-1}	12.37 bc	21.10 l	16.31 p	77.29 g	11.10 pq
Residual FYM 20 t ha^{-1}	12.34 d	21.26 k	16.47 o	75.66 h	11.24 o
Residual PM 10 t ha^{-1}	12.37 bc	21.46 j	16.64 n	77.52 g	11.36 n
Residual PM 20 t ha^{-1}	12.35 cd	21.76 i	16.90 m	77.66 g	11.55 m
Residual BF 5 t ha^{-1}	12.40 a	20.96 m	16.22 q	77.38 g	11.06 q
Residual BF 10 t ha^{-1}	12.34 d	21.16 kl	16.36 p	76.95 g	11.13 p
Residual FYM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	12.31 e	23.26 c	19.70 d	84.66 g	14.34 d
Residual FYM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	12.28 f	23.46 b	19.89 c	84.78 abc	14.49 c
Residual PM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	12.25 g	23.38bc	20.03 b	85.00 abc	14.62 b
Residual PM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	12.23 gh	23.70 a	20.21 a	85.27 a	14.78 a
Residual BF 5 t ha^{-1} + Three-fourth of Recommended (169-84-126)	12.36 cd	22.86 ef	19.06 g	83.35 cde	13.72 g
Residual BF 10 t ha^{1} + Three-fourth of Recommended (169-84-126)	12.34 d	22.96de	19.17 f	83.47bcde	13.82 f
Residual FYM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.38 b	22.66 g	18.29 j	80.68 f	12.86 j
Residual FYM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.35 cd	22.76 fg	18.38 i	80.75 f	12.94 j
Residual PM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.31 e	22.86 ef	18.85 h	82.45 e	13.47 i
Residual PM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.29 ef	22.96de	19.03 g	82.85 de	13.64 h
Residual BF 5 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.41 a	21.86 i	17.33 l	79.26 f	12.03 l
Residual BF 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	12.36 bcd	22.13 h	17.64 k	79.71 f	12.30 k
S.E	0.110	0.0611	0.0329	0.7807	0.0374
LSD (5%)	0.223	0.1237	0.0665	1.5805	0.0756

Table 4. Effect of supplemental inorganic NPK and residual organic nutrient sources on NPK Concentration and uptake of sugarcane ratoon crop.

Treatments	N (%)	P (%)	K (%)	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Control (0-0-0)	1.08 i	0.20 i	1.17 h	72.26 l	13.78 k	78.22 j
Recommended (225-112-168)	1.29 bc	0.35 abc	1.51 abcd	130.70 c	35.80 bc	152.98 b
Residual FYM 10 t ha^{-1}	1.12 gh	0.33 cd	1.43 cde	76.49 k	22.76 ghi	97.57 hi
Residual FYM 20 t ha^{-1}	1.03 j	0.34 cd	1.56 ab	71.39 l	23.55 gh	107.97 fgh
Residual PM 10 t ha^{-1}	1.23 d	0.34 cd	1.52abc	89.73 hi	25.05 fg	115.90 defg
Residual PM 20 t ha^{-1}	1.17 ef	0.27 f	1.50 abcd	86.29 i	20.24 j	110.86 efgh
Residual BF 5 t ha^{-1}	1.16 ef	0.30 e	1.50 abcd	79.59 jk	20.82 ij	102.82 gh
Residual BF 10 t ha^{-1}	1.27 c	0.34 cd	1.25 gh	86.27 i	23.33 gh	84.91 ij
Residual FYM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	1.30bc	0.35 bc	1.44 bcde	146.98 a	37.92 b	156.36 ab
Residual FYM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	1.35 a	0.37 a	1.39 def	143.31 b	40.93 a	151.36 b
Residual PM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	1.29 bc	0.33 cd	1.44 bcde	121.45 a	37.06 bc	160.05 ab
Residual PM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	1.35 a	0.37 ab	1.59a	150.14 b	40.94 a	168.95 a
Residual BF 5 t ha^{-1} + Three-fourth of Recommended (169-84-126)	1.32 ab	0.32 de	1.37 def	110.73 d	29.78 d	126.03 cd
Residual BF 10 t ha-$^{-1}$ + Three-fourth of Recommended (169-84-126)	1.19 e	0.37 a	1.43 cde	91.23 e	34.73 c	132.97 c
Residual FYM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.09 hi	0.32 de	1.46 bcde	97.78 h	27.07 ef	121.69 cdef
Residual FYM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.15 fg	0.32 de	1.50 abcd	100.63 g	27.50 de	127.42 cd
Residual PM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.13 fg	0.25 gh	1.25 gh	104.18 fg	22.15 hij	111.27 efgh
Residual PM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.14 fg	0.23 h	1.37 efg	80.96 f	21.37 hij	124.77 cde
Residual BF 5 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.02 j	0.27 fg	1.23 h	92.80 j	21.43 hij	97.55 hi
Residual BF 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	1.16 ef	0.25 fgh	1.27 fgh	92.80 h	20.30 j	101.21 h
S.E	0.0188	0.0122	0.0628	1.8099	1.1748	6.945
LSD (5%)	0.038	0.024	0.127	3.664	2.378	14.061

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

Treatments	Cane yield	Revenue productivity	Cost of production	Net Return	Cost Benefit Ratio
Control (0-0-0)	30.66	76650	0	-	-
Recommended (225-112-168)	95.73	239325	33386	129289	4.87
Residual FYM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	106.33	265825	25040	164135	7.55
Residual FYM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	119.66	299150	25040	197460	8.88
Residual PM 10 t ha^{-1} + Three-fourth of Recommended (169-84-126)	108	270000	25040	168310	7.72
Residual PM 20 t ha^{-1} + Three-fourth of Recommended (169-84-126)	121.33	303325	25040	201635	9.05
Residual BF 5 t ha^{-1} + Three-fourth of Recommended (169-84-126)	89.86	224650	25040	122960	5.91
Residual BF 10 t ha-$^{-1}$ + Three-fourth of Recommended (169-84-126)	91.51	228775	25040	127085	6.07
Residual FYM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	75.23	188075	16694	94731	6.67
Residual FYM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	79.04	197600	16694	104256	7.24
Residual PM 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	75.44	188600	16694	95256	6.7
Residual PM 20 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	78.07	195175	16694	101831	7.09
Residual BF 5 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	70.33	175825	16694	82481	5.94
Residual BF 10 t ha^{-1} + Half of Recommende.NPK (112-56.-84)	72.5	181250	16694	87906	6.26

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