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Integrated Nutrient Management System: Smart way to improve cane production from sugarcane ratoon

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ABSTRACT

Sugarcane ratooning is old age practice, due to heavy investment of input and crop itself provides good ratoonability hence it is not required to go for each time seeding /planting new crops. Sugarcane is heavy feeder of nutrient, it remove massive quantity of nutrient from soil if not provided improper amount and time. For efficient ratooning and to make it more profitable and sustainable, integrated nutrient management system (INMS) is way to harness production potential of sugarcane ratoon, marching ahead with nature in sustainable manner.

Keywords: Good Agronomic Practice, INMS, Nutrient management, Ratoon, Sugarcane

INTRODUCTION

Sugar beet and sugarcane is two major contributors to the global sugar production, sugarcane contributes about 65% of the total world sugar production (Singh, 2006 and Raghuraj *et al*., 2015). Sugarcane is the most important commercial sugar crop of India; it is the largest consumer and second largest producer of sugar in the world after Brazil. India's sugar production has increased in last 10 years at CAGR of 2.63 percent. During the same period, India's sugarcane production has increased at CAGR of 2.40 percent and area under cultivation at CAGR of 3.19 percent (DAC, 2015). India is well known for its quality gur, khandsari and sugar a produce derived from sugarcane, evidence of sugarcane cultivation in India is found that it's started during *Pre Vedic period*. It is mentioned in Sanskrit (one of the oldest language in India) by name of *Ikshu* & *Ikshura* and the sugar is called sarkara or sakkara (Rana and Singh, 2003). It has been estimated that during 2014-15, India produced record 3593.3 Lakh Tonnes of sugarcane and 250.46 Lakh Tonnes of sugar (Table 1). The productivity of sugarcane is 71.41t/ha, ratoon productivity is further low , thus sugarcane productivity in India is much lower than of other sugarcane producing countries like Ethiopia(108 t/ha), Kenya (105 t/ha) and Swaziland (98 t/ha). Not only cane tonnage but sugar productivity is also low in India (7.09t/ha.) as compared to other sugar growing countries viz., Hawaii (17.3 t/ha) Australia (11.4 t/ha) and West Indies (11.1 t/ha). In India, 90 % area of sugarcane is under assured irrigation. The sugary recovery percentage in India is 10.36 %. Sugarcane ratooning is common and profitable practices in all most all cane growing parts in this country and aboard as well. Generally once planted cane can be used for taking at least one plant and two successive ratoon profitable with the use of good management practice (GAP) (Singh *et al.*, 2012b) and selecting correct variety having good ratoonability (Agarwal *et al*., 1974 and Devaraj *et al*., 1973). There are numerous example of taking more than 2-3 ratoon crops, in long term experiment successfully eight ratoon crops has been raised (Rana *et al*., 2003). Though there are several factors like soil and climatic variation, poor pest and disease management, ratooning ability of varieties, harvesting date of planted crop etc effecting yield and quality of sugarcane ratoon crop. But one of the most important factors is nutrient management in sugarcane in general and ratoon crops in particular, because the ratoon crops are generally ill managed for nutrients (Rana *et al*., 2002). For obtaining good ratoon yield, there is urgent need to adopt appropriate agronomic practices (like harvesting date, height of harvesting, cutting stubble saving, off barring), nutrient management is one of the

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most important factors affecting tonnage of ratoon cane (Rana and Singh, 2003).Though there are several factors like soil and climatic variation, poor pest and disease management, ratooning ability of varieties, harvesting date of planted crop etc effecting yield and quality of sugarcane ratoon crop (Singh *et al.*, 2012a and Rana *et al.*, 2003). Sugarcane is crop of high response to its added inputs, soils often unable to match the supply during peak period of its demand, hence supplementing nutrition by organic or inorganic sources is obvious for producing targeted yield. Availability of high yielding varieties (Singh *et al.*, 2008; Agarwal *et al.*, 1974 and Devaraj *et al.*, 1973), which are highly input responsive and indiscriminate use of high analysis chemical manure and limited recycling of farm organic materials resulted in imbalance in imbalance in general for agricultural production system and sugarcane in particular being highly input responsive crop owing to C4 pathway of carbon assimilation (Singh *et al.*, 2012a).

Table 1: Production, area under cultivation and yield of sugarcane and sugar

Crop/ Marking Year	Area (lakh ha)	Production (Lakh Tonnes)		Sugarcane Yield (tonnes/ ha)
		Sugarcane	Sugar	
2005-06	42.0	2811.7	193.2	66.92
2006-07	51.5	3555.2	282.0	69.02
2007-08	50.6	3481.9	263.0	68.88
2008-09	44.2	2850.3	146.8	64.55
2009-10	41.7	2923.0	188.0	70.02
2010-11	48.8	3423.8	243.5	70.09
2011-12	50.4	3610.4	263.4	71.67
2012-13	49.99	3412.0	258.5	68.25
2013-14	50.12	3521.4	245.5	69.84
2014-15	50.32	3593.3#	250.46	70.86

#: As per 4th Advance Estimate (2014-15) of Department of Agriculture and Cooperation, GOI India
Source: Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India

Integrated Nutrient Management System and its importance

To obtain maximum production potential of a particular crop depends on the environment and the skill of the farmers in identifying and eliminating those factors that reduce the production potential. The high tonnage of sugarcane will certainly requires more plant nutrition. The essential nutrients required by higher plant are exclusively of inorganic nature (Singh *et al.*, 2012a). According to the criteria of plant nutrition, at least 16 chemical elements are known to be essential for sugarcane. Major portion is covered by Carbon (C), Hydrogen (H) and Oxygen (O) which is managed by air and water. Others like N, P, K, S, Ca, etc are needed in less amount and need to suppliant is soil is not able to supply them in adequate amount (ICAR, 2006).Integrated Nutrient Management System (INMS) in sugarcane crop receiving more attention in modern agriculture than ever. As we know sugarcane is heavy feeder of nutrients. On an average its remove 250 Kg N, 60 Kg P, 304 Kg Fe, 1.2 Kg Mn0.6 kg Zn and 0.2 kg /ha Cu respectively, from soil by a good crop of 100 t/ha. That's why the farmer applies heavy dose of fertilizer simultaneously more wastage of nutrient particular nitrogen also exists in sugarcane field (Kumar *et al.*, 2007). INMS involves the use of chemical fertilizers in conjunction with organic manure's/wastes coupled with inputs through biological processes (Singh *et al.*, 2012a). The results of a large number of experiments on manure's and fertilizers conducted in the country reveal that neither the chemical fertilizer alone nor the organic sources exclusively can achieve the production sustainability of soil as well as crops under a highly intensive cropping system (Yadav, 1994). The INMS has proved superior to the use of its each component separately. Besides the interactive advantages of combining organic and inorganic sources of nutrients the present level of fertilizer production in India is not enough to meet the total plant nutrient requirement. The gap between demand and supply of fertilizer is expected to widen further and it may be reach 15-20 million tones by 2020 AD. It is estimated that organic and bio fertilizer may help to bridge this gap by supplying 6-million tones of plant nutrients, where as soils and efficient use of plant nutrients may contribute to the extent of 3 million tons (Singh *et al.*, 2012a and Singh and Singh 1992). The INMS helps to restore and sustain soil fertility and crop productivity. It may also help to check the emerging deficiencies of Nutrients ether than N, P and K. Further; it brings economy and efficiency in fertilizers. The INMS favorably affects the physical, chemical and biological environments of the soils (Kumar *et al.*, 2007 and Singh *et al.*, 2012a).

COMPONENT OF INMS

INMS consists of uses of inorganic fertilizers, sugarcane based cropping system, uses of legume as a green manure; as inter crop, uses of organic manure, crop residue management and incorporation of factory waste, recently developed bio fertilizer (Rana *et al.*, 2003; Kumar *et al.*, 2007 and Singh *et al.*, 2012). Each

component is discussed briefly. **Inorganic fertilizer:** In modern agriculture chemical fertilizer is chief source of nutrient supply for getting better response chemical fertilizer allowing factor are responsible. Use of proper kind and form of high analysis chemical fertilizer and their appropriate time and mode of nutrient application for feed the crop to take optimum production, different kind of fertilizer in market which are:

Nitrogenous fertilizer: Amongst plant nutrients essential for growth, nitrogen is of prime importance in sugarcane. Though constitutes only a fraction of one per cent of the total dry weight of matured sugarcane plant yet it plays an important role, as important as carbon Hydrogen and Oxygen, which all together constitutes more than 90 per cent of the dry matter. Nitrogen is transported from roots to the leaves where the process of assimilation takes place and it is transformed in to protein a substance which constitutes an important part of protoplasm, growth is usually rapid with abundance of carbohydrate and nitrogenous compounds. Nitrogen is the constituent of all the enzyme systems influencing the various physiological functions in the plants. Sugarcane is being grown in the area of 5.03 million ha which occupied 3.45 % of total cropped area of country (DAC, 2015). It has been also observed that if the applied nutrient is managed properly or reduced the losses of nitrogen by following way then the present quantity of N fertilizer will be sufficient for further also. Nitrogen can be liberate from soil environment which make its practically very difficult to utilized by plant for its requirement, the region could be denitrification, NH_3^+ volatilization, NO_3^+ Leaching, NH_4^+ Fixation or some time biological immobilization by bacterial activities. Factor is responsible for the above losses may be faulty management of irrigation water, improper time, mode and amount of N application ,improper selection of form and kind of N fertilizers, poor and faulty weed management practices, soil type and its pH and agro climatic condition of the particular region. For obtaining good fertilizer use efficiency choice of correct kind and form of fertilizer is necessary, in case of sugarcane urea and ammonium sulphate is most effective chemical fertilizer (Rana *et al*., 2002 and Singh *et al*., 2012a).

Time and mode of nitrogen application: Nutrient absorbed by sugarcane plant during tillering phase dose not exceeds 25-30% of its total nutrient absorbed up to the maturity stage. Initial high concentration of nitrogen in sugarcane crop is necessary because during this stages tillers are coming out which ultimately converted in to millable canes otherwise their will lesser number of cane which adversely affects the yield potential (Rana *et al*., 2002). This can be achieving by applying the full dose of fertilizer at formative phase of crop. Total early fertilization preferably at planting time lead to the maximum cane yields and better juice quality, clearly indicated early requirement of nitrogenous substances. In case of short duration cultivars, with assured irrigated condition application of nitrogen @ 150 kg N/ha at planting in furrow is good, but higher dose may be provided in 3 split application in subtropical condition. First foliar application 40-90 days after sowing found superior to delay fertilization (Rana *et al*., 2003). As we knew sugarcane is long duration crop and nitrogen is needed over all growing the season because it's vegetative portion (stalk) is economic produce hence to the check denitrification losses from sugarcane field number of agricultural chemical including nematicides pesticide and fungicide like N-serve, *Nitrepyrine*, AM, Thiourea, Potassium azide etc. are useful and available in the market (Singh *et al*., 2012a). Nitrogen is one of the most important limiting nutrients for crop production so sever a1 worker studied the effect of nitrogen nutrient on the growth yield and quality parameter. There is general trend that due to increasing rate of N fertilizer growth and yield was increases up to some maximum but quality of cane juice is reduced with increasing rate of N application. Mane and Salunkhe (1978) observed that after 4 year of field trails with sugarcane cv. Co 740 the effect were compared of N at 170, 250 and 335 kg/ha applied to the plant cane first ratoon and second ratoon respectively. The ratoon crop produced higher can yields and their canes matured earlier and were of better quality than the plant crop. Cane yields of all crops rose with increasing N levels. Zambello *et al.* (1980) studies the sugarcane ratoon cv. GB 4116 on different soil N at 60-180 Kg/ha was applied surface or subsurface. Generally the method of fertilizer placement had no appreciable effect on cane or sugar yield and the yield rose with N rate. Gotera *et al.* (1980) Data reviled that N application to plant crop had no effect on tonnage, that highest sugar production offirst ratoon crop was obtained with 190 kg N/ha regardless of the N history of plant crop. Rathi and Singh (1982) while working at Kanpur reported that first ratoon crop of sugarcane cv. CO 1148 received nitrogen at 40-280 Kg/ha, sugar yield rose significantly with N rate up to 160 kg N/ha after which rise was very slight however there was slight cane juice quality deterioration at the higher rate of nitrogen application. Yadav (1983) studied with cv. CO 1148 and CO 1158. Nitrogen was applied @ 75-225 kg/ha in the previous year to the plant crop and 50-150 kg N/ha to ratoon crop, ratoon yield response was obtained in the range of 55-58 t/ha in both the cultivator in plot with 225

kg N/ha (residue) +100 kg N/ha (direct). The control yield was 25.28 t/ha. CO 1148 gave higher yield than CO 1158 Acosta *et al.* (1985) N application (30-180 kg/ha) as urea decreases or had little effect on Cane and sugar yield in plant and first ratoon Cane of 14 cultivar. Compared with control had increased cane and sugar yield in second ratoon crop (my up to 21.7%, 24.2% respectively. Yadav *et al.* (1990) reported from Lucknow that ratoon cane cv. CO1148 was received 0 or 150 kg N/ha. N application increased cane yield but reduced juice quality. Chauhan *et al.* (1991) observed that sugarcane cv CO1148 was grown on sandy soil was given (0-225 kg N/ha to ratoon cane yield increase up to 150 kg N/ha. Cultivar CoC 671 and Co 6304 were give 75, 100 or 125% of recommended N fertilizer rate, average cane yield was higher in CO 6304 (102.91 T/ha) than CoC 671 (97.6 T/ha). Kapoor *et al.* (1993) studied that sugarcane cv CoJ64 was grown on loam soil. Apply 0, 112.5,225 or 337.5 Kg N/ha to ratoon. There were no significant differences in millable cane yield of ratoon increased up to 337.5 kg N/ha. Yadav (1993) reported that pool data from several locations of India indicated that the N application was ranged to sugarcane from 60 to 400 kg N/ha and can yield ranged 21.5 to 305 t/h. While the yield responses, cane/kg N applied was highest in 60 kg N (4.5q cane/kg) and lowest in highest N dose (1.8q cane/kg).

Table 2: Response of sugarcane to nitrogen at different place in India

Location	Variety	N (kg/ha)	Cane yield (t/ha)	Yield response (q cane/kg)
Padgaon	C0740	400	76.5	1.96
Rahuri	Co7219	400	80.5	1.90
Kolhapur	C07529	400	77.6	1.85
Mandaya	C0419	250	122.1	1.24
Sehore	C06304	300	61.0	0.72
Pusa	B0108	120	29.8	3.5
Lucknow	C01148	150	47.1	1.20
Shahjahanpur	Co 767	150	56.0	1.86
Jalandhar	CoJ 64	150	49.8	1.44
Burallkshn	CoJ 64	60	21..5	4.50

Phosphorus fertilizers: Sugarcane is not responding earlier to P application in most of the soils. With increasing deficiency of P in Indian soils in recent years sugarcane has responded to P application (Kumarswami and Rajasekaran, 1994). The yield of millable cane is increased by 1.43 to 3.0, 2.73 and 1.0 q in plant cane first and second ratoons respectively over control. P is generally applied as Basal and mostly water soluble from of Phosphorus are applied i.e. Single Super Phosphate (SSP), Di Ammonium Phosphate (DAP). Phosphorus is one of the essential nutrient also known as key elements for plant life it maintain the adverse effect of high application of nitrogen fertilizer. Several worker reported that app1lication of phosphorus fertilizer has positive effect on ratoon cane. Morelli *et al.*(1991) working at Sao Paulo, Brazil, reported that an experiment was carried out in quartz sandy soil (3-ppm p) to evaluate the effects of thermophosphate broadcast and furrow applied on the soil chemical properties and sugarcane yield. The broadcast P_20_5 rates were 0, 200 and 400 kg/ha, and 0,100, 200 and 300 kg P_2O_5/ha were applied in the furrow. Yields were higher in the Broad cast both for plant cane and first ratoon. The treatment with 200 kg P_2O_5 /ha broadcast + 100 kg P_2O_5 furrow applied was the most economical. Ball *et al.* (1993). A sequential P fractionation procedure was used to examine short-term dynamics of P from fertilizer residue returns. Soil and long term changes in forms and quantities of soil P as result of fertilization. Mulch and barn systems of residue management were imposed on field grown sugarcane in northeast Brazil. Both treatments had similar in puts of P from residues (8.7 kg/ha) but despite the higher available P content of the ashes, more of the added p was mobilized and taken up by the plant in the mulch system. Due to the presence of roots with in the decomposing litter and more intense root exploration on the top soils a result of an improved moisture regime. This improved moisture and P supply was reflected in 45% greater yield in the mulch treated ratoon cane. Fertilizer P applied in a furrow 20 cm deep with the plant crop was concentrated in the mere labile fractions and had a residual effect on the first ratoon or 30% over the long term (10 x 2). There was accumulation of 144 kg/ha of fertilizer P in the top 30-cm soil. Kumarswami and Rajasekaran (1993) reported from Cuddalore, Tamilnadu that field trial was conducted on sandy loam soil; sugarcane cv. CoC 85061 was given 0, 60 or 90 kg P_20_5 /ha either all at sowing or all at 30 days after sowing (DAS), in 2-3 split applications. Cane yield was not affected by P rate, but among application dates was highest when all P was applied 30 days after sowing and 10west with application in 3 equal splits at 30, 60 and 90 DAS. Yield of the following ratoon crop was not significantly affected by residual effect of P rate. Patel *et al.* (1993) reported from Navsari, in field experiments in (winter) rabi season of 1988-92 the highest cane yields of sugarcane cv. Co 6034 were produced by applying 125 kg P/ha to the plant crap and the first and second ratoon. Although application of 62.5 kg P/ha to each crap produced similar results. It was concluded that with one ratoon/year, 125 kg P is needed

annually to give maximum yields, but if two ratoons are produced, 125 Kg P should be applied to the 1st ratoon and 52.5 Kg to the second due to residual effect from the first P application. Pereira *et al.* (1995) while working at Juazeriro, Brazil, reported that sugarcane cv.BR 70-194 was given 0, 60, 120, 180, 240 or 300 kg P_2O_5 /ha, after harvesting the sugarcane half of each plot was given 90 kg P_20_5 /ha. The P rate had a quadratic effect on can yield and the concentration in the leaves. The yield of the ratoon crop in the treatments that did not receive a second P application varied from 45.31 to 78.93 % of that of those that had received a second application. P concentration in the juice increased with increasing P rate.

Potash: This nutrient require larger amount than Nitrogen because it roll in photosynthesis, Translocation of sugar, protein synthesis, so its requirement is made overall growth period, so initial basal application is better and generally, (K_2SO_4) potassium sulphate, murate of potash (KCl) are used as source of potassium. Potassium fertilizer is one of the essential fertilizers, which is some time required largest amount than nitrogen because it needed for translocation and storage of sugarcane. There is negative interaction i.e. lower level of N; K reduced the yield response of Potassium fertilizer on sugarcane is revealed by several workers. Bhatti (1989) working at Ayab Agricultural Research Unit, Faisalabad from 1976-79 to 1985 to 1986 the soil and crop response to long term K fertilizer application was determined. K fertilizer was applied at sowing the sugarcane yield was only increased in the last tow season. K application showed a positive effect on yield of wheat grown after sugarcane. Soil K was reduced in the ratoon from 200 mg K/ha in 1978 to 180 mg K/ha in 1986.Said *et al.* (1990) reported that in 1986-87 and 1987-88 sugarcane cv. CP48/103 CP 51/219, CP 65/357 and LC 62/96 were given 0 100, 200 or 300Kg K_2O /ha + 120 kg N and 100 kg P/ha. Mean Cane yield of plant and ratoon crops increase with increasing K_2O rate. K_2O rate significantly affect mean cane commercial sugar, percentage (CCS %) of the plant crop but had significant effect on that of the ratoon crop, K_2O up to 200 kg/ha give lower values than the control. But K_2O at 300 kg/ha giving the maximum sugar recovery (10.7%) significant effects of K_2O rate on mean sugar yield were only seen in plant crop. 100 kg K_2O had given the highest yield (59.91 t). The highest cane yield and CCS % in ratoon (59.16 t/ha) and 11.61 % respectively) in the sugar cane ratoon crop, sugar yield was highest (6.2 t/ha) in CP 65357 without K_2O application.

Sulfur: The responses of sugarcane are no more limited to only NPK. Sugarcane has responded to S, generally sulphur is not applied , sugarcane responses well to sulfur application. Sulfur is give through Ammonium Sulphate (23.7%), and Pyrites (53.5%) etc. Generally the requirement is more in poaceae plant as compare to leguminaceous because it play vital role in oxidoreduction process of respiration because it a plant of feredoxins. Yadav (1993) working at Lucknow reported that application of sulfur @ 30 kg/ha to plant and ratoon Cane as basal. Sugarcane has responded to each kilogram of soil applied S over control by 3.4 and 2.85 q millable Cane in plant cane and first ratoon respectively. Golden (1982) reported that sugarcane cv. CP 52-68 and NS Co 310 on 3 soil types. N as basal dressing at 160 lb/acre was applied alone (control) or with P205 (174 Ib/acre) and or S (24Ib/ acre) in various combinations data are tabulated on leaf P and S contents. Cane yield ranged from 25.55t/acre receiving N only to 35.38 t/acre on receiving all three nutrient.

Micro nutrients: Plant taken in the form of Zn^{2+}. It is applied through soil but foliar feeding can also be done. Most important source is $ZnSO_4.H_20$ (35% Zn). Juanj and Chani (1919) observed that zinc at 25 or 50 kg/ha was soil applied. Two or four field trials with autumn planted cane showed a significant response to Zn in both cane and sugar yields. A similar trend was noted in ratoon cane (Juang *et al.*, 1979). Velu (1989) reported that Zn was applied to cv. Co 419 via the black calcareous soil or via the foliage. The highest cane yield 133.4 t/ha was obtained with Zn application. It compared with 88 T/ ha in the control received basal NPK. The effect of leaf balance of Fe/Mn and Zn on cane growth is discussed. A significant relationship was found between cane or sugar yield and soil Zn content, after harvest maximum yield of both cane and sugar occurred when soil Zn was about 12 and 18 PPM for autumn and ratoon cane respectively. Other micronutrients like Fe, Mn is also responded to sugarcane they are also applied through soil as basal but foliar application can also be done. The chief source is $FeSO_4$ and $MnSO_4$ for Fe and Mn respectively.

2. SUGARCANE BASED CROPPING SYSTEM

The plant crop of sugarcane is invariable, followed by a ratoon crop; mostly one to two ratoons are taken, however the crop preceding sugarcane and succeeding ratoon crop varies in different agroclimatic and socio-economic situations (Kumarswami *et al.*, 1995; Parasar and Prasad, 1985 and Willey, 1990). The INMS favorably affects the physical, chemical and biological environments of soils. Some of the important sugarcane

based cropping system prevalent in the country is listed in Table 3. Sugarcane based cropping system being at least of 3-4 years duration in complex in its nutrient use pattern. The choice of crop preceding sugarcane is important and its play a vital role in the successful sugarcane based cropping system (Rana *et al*., 2003). Sugarcane has a considerable bearing on the additional nutrient requirement for itself. Need for nitrogenous fertilizer is about 50 % higher in following ratoon crop but the requirement for phosphorus is comparatively low because of the availability of residual phosphorus. A system approach of nutrient management for sugarcane cropping as a whole is therefore, considered much efficient, the quantification of fertilizer economy is possible only when the fertilizer needs and residual carryover of the full cropping cycle as against the individual crop are known, very limited studies on INMS in sugarcane and sugarcane based cropping system have been conducted. The optimum dose of nitrogen were worked out for sugarcane are 152, 175, 186, 231 Kg/ha, when grown in association with potato, coriander, mustard and wheat, fertilized with 120, 150, 60 and 100 kg N/ha respectively. INMS helps to restore and sustain soil fertility and crop productivity it may also help, to check the emerging deficiencies of nutrients other than N, P and K further it brings economy and efficiency in fertilizers. The INMS favorably affects the physical, chemical and biological environments of soils (Rana *et al*., 2003 and Kumar *et al*., 2007).

On the basis of study mentioned in table 4 one should go for legume inter cropping with sugarcane, there is slightly decrease in cane yield but additional yield of legume was obtained through intercropping with legume, which is mere remunerative than sugarcane alone. Rathi and Singh (1979) working at Kanpur reported that sugarcane ratoon yields were enhanced by most of the intercropping tested, either alone or in sequence, the highest yield was obtained with sugarcane + potato followed by onions,; juice quality was also not affected negatively. Dhutada and Parashar (1981) While testing the sugarcane cv. Co 1148 was grown alone or intercropped with (2) onions (2) mung beans, (4) cowpeas (5) urd bean. The cane received N at 100 or 150 kg/ha and the intercrops were fertilized separately according to the schedule prescribed for each crop. Cane yield in (1), (2), (3), (4) and (5) was 59.6, 51.3,57.9,51.9 and 50.0 t/ha ,respectively. Application of N at 100Kg/ ha was adequate for the 1st ratoon crop.as reported by Suryani and Rasjid (1994) while working in Indonesia observed that sugarcane cv. PS 58 was grown alone or intercropped with mung beans established two weeks

Table 3: Sugarcane based cropping system in different sates in India

Sugarcane based cropping system	**States**
Rice (early)- Pea +sugarcane plant-first ratoon- wheat	Eastern U. P.
Rice (early)- sugarcane (autumn) first ratoon -wheat	Eastern U. P.
Green manuring- sugarcane plant-first ratoon	Eastern U. P.
Rice-potato-sugarcane plant first ratoon-wheat	Western U.P.
Rice –wheat-mustard-sugarcane plant- first ratoon- wheat	Western U.P.
Green manuring - potato +sugarcane plant-first ratoon -wheat	Western U.P.
Maize (early)- potato +sugarcane plant- first ratoon	Western U.P.
Sorghum -gram or potato (early)- sugarcane plant +first ratoon	Bihar
Rice + pigeon pea- green manuring-sugarcane plant+ first ratoon	Bihar
Rice-pea-sugarcane plant-first ratoon	Bihar
Fallow-wheat-green manuring-sugarcane plant- first ratoon	Bihar
Maize-wheat-sugarcane p1ant-first ratoon-wheat	Punjab, Hayana, Western U.P.
Chari- berseem-sugarcane plant-first ratoon	Punjab
Ground nut-wheat -sugarcane plant- first ratoon	Gujarat
Cotton-sugarcane plant-first ratoon	Maharastra
Rice - sugarcane plant- first ratoon	Maharastra
Ragi- sugarcane plant- first ratoon	Maharastra

before ratooning or two week after ratooning. Growth and yield of sugarcane was generally unaffected by mung beans sowing date late sowing decreased growth and seed yield of mung beans for ease of cultivation. It is suggested that mung beans should be sown at ratooning.

3. Legumes in INMS

In general the removal of plant nutrient is more in cereal crops than the legume crops therefore; legume is preferred to be included in crop sequence to sustain soil productivity (Willey, 1990). The legume in sugarcane farming system is grown as **(a) Legume in crop rotation:** Sugarcane based cropping systems are commonly practiced in different state of India (Parasar and Prasad, 1985). The sugarcane based cropping system is listed in table 3. **(b) Legume as green manuring crops**: Before the chemical fertilizers come in use in sugarcane farming system green manuring was consider as a dispensable practices. As result of that there was general recommendation to north India ½ to 2/3 nutrients apply through green manuring or organic manure. The principle green manuring crops included sunhemp, dhaincha, bean, guar sainji, berseem, menthi, pea, khesari and lentil. Spring planted sugarcane was usually grown in field kept fallow or green manured during mansoon season for getting higher cane yield. The green manuring of legume crops give benefit of 19-43% increase in the yield of spring sugarcane, however spring sugarcane is not able to derive full benefits of green manuring of Kharif season. **(c) Legume as inter crops:** Sugarcane is planted generally at in row 60-90 cm. It's normally take 30-45 day for germination and the initial growth of crops is also slow up to 100 day after planting and also in case of ratoon (Singh and Singh,1992; Prasad, 1985). As a result of the laetrile spread of crop, foliage is not much, secondly green manuring prior to sugarcane is considered as waste full practices because of population pressure on land and availability of chemical fertilizer at cheaper rate. Its not preferred to miss a kharif crops for green manuring so legume in inter row spaces as intercrop is taken. Legumes suitable for intercropping with sugarcane, in autumn planted sugarcane ratoon, berseem, gram, lentil, pea, khesari and for spring planted cane ratoon, summer legume like moong, urd, and cowpea are popular intercrop (Table 4).

4. Organic Manure

Organic manures playa direct role in supplying macro and micronutrient and an indirect one by improving the physical chemical biological properties of soil. Farm yard manure, compost and oil cake from groundnut castor

Table 4: Effect of intercropped on sugarcane yield

Intercropped Legume	Yield of crops (t/ha)			
	Lucknow		New Delhi	
	Sugarcane	Legume	Sugarcane	Legume
Sugarcane	110	-	50	-
Moong	113	0.42	59	0.46
Black gram	129	0.51	-	-
Soybean	103	1.32	-	-
Cow pea	106	0.51	57	0.45
CD (5%)	22.3	0.31	NS	0.28

mustard mahua, safflower etc. are very commonly used in sugarcane for increasing cane yield and improving soil fertility (Kumarswami *et al*., 1995; Rana *et al*., 2003). These organic manure were bulky slow in response and less effective than chemica1 fertilizer. A comparison of efficiency of manures would indicate that N- contained in bulky organic manures are nearly 40-50% as effective as that out aired in chemical fertilizer. The observation may lead to conclude that organic manures are inferior to chemical fertilizer, therefore, to derive the full benefits of organic manures an integrated use of with chemical fertilizer has been emphasized and advocated. Further looking in to the long-range effect ever 10 cropping system reveal that compared application of organic and inorganic form of nutrients maintains and improved the crop productivity by affecting the soil properties (Table 5). Organic manures playa direct role in supplying macro and micronutrient and in direct one by improving the physical chemical and biological environment. Further effect over 10 cropping seasons reveal that combined application of organic and inorganic manure maintains and improve the crop productivity by affecting the soil properties this study was done by Robindra *et al.* (1996**)**.

Table 5: Long term (1971-1982) effect of manures and fertilizers on yield of sugarcane and physical properties of soils

Treatments	Yield (t/ha)	Bulk Density	WHC (%)	Organic Carbon (%)
Initial value	-	1.8	30	0.68
Control	28	2.0	29	0.40
NPK, N as urea	114	1.75	35	0.76
NPK N as A/S	108	1.82	34.6	0.70
FYM 25 t	56	1.72	38.6	0.70
NPK equ. to 25 t FYM N as A/S	48	1.82	32	0.57
Same as above+ NPKN as urea	111	1.80	34.6	0.61
NPK + 25 t FIM	120	1.66	38	0.78

On the basis of this data they concluded that chemical fertilizer are superior over organic manure but castor cake had good response than any other treatments but in case of N response inorganic fertilizer was superior over organic fertilizer.

5. Crop residues in INMS

The crop residues like green foliage of crops cane trash; rice and wheat straw etc. have been recycled in sugarcane cultivation. As a result economy in fertilizer N has been affected (Kumarswami *et al*., 1995; Rana *et al*., 2003). The addition of green leaves from outside has the some effect as above ground portion of green manure incorporated in soil *Glyricidia*, Karanj (*Pongamia glabra*) and Arak (*Caletropis gigantea*) are very popular in south India for green leaf manuring. Potato foliage containing; 2.6-2.7 % N contributes 31 kg N/ha when use as green manure, it increase the yield of Sugarcane by 5.0t/ha where as intercropping of potato increase the cane yield by 7.0 t/ha over sugarcane alone. Trash is the residue of sugarcane and on an average one hectare sugarcane field provide 8-10 t/ha trash. Incorporation of trash with fertilizer N increases the cane yield. May also increase in cane yield by 30% over control when 5.0 t/ha trash is incorporated with 75 kg N/ha and economy of 75 kg N/ha been obtained in south India. Shinde *et al.* (1993) studied the incorporation of sugarcane trash in ratoon and pool data revealed that the cane yield was significantly influenced due to various treatments. All the treatments of trash incorporation were found significantly superior over control. The incorporation of chopped trash @ 7.5 t/ha gives highest cane yield. However this treatment was on par with the treatment of unchopped trash added in same quantities (Table 6). Durai (1991) working research for low yields of sugarcane ratoon crops is discussed cultural practices to increase yield. Find that ratoon cane yield with all recommended practices (103.0 t/ha), without cultural practices (90.4 t/ha) and trash mulching from recommended practices gave yield of 105.7 t/ha.

Table 6: Effect of incorporation of sugarcane trash in ratoon, on growth parameter and cane yield (cv. Co 741)

Treatments(t/ha)	Millable Cane (000/ha)	Millable Cane height (cm)	Cane Yield (t/ha)
Chopped trash @ 2.5	82	164	80
Chopped trash @ 5.0	87	175	87
Chopped trash @ 7.5	88	180	90
Unchopped trash @ 2.5	83	163	79
Unchopped trash @ 5.0	84	170	85
Unchopped trash @ 7.5	86	176	87
Trash burning	82	166	79
Control	81	161	78
CD (P= 0.05)	NS	NS	2.1

6. Factory wastes in INMS in Sugarcane ratoon

The by-products of factories like seen waste from distillery, molasses and press mud cake etc from sugar industry have been reported to increase the yield of cane (Singh and Singh, 1992). The production of press mud cakes (PMCs) is about 3 to 7 percent of the amount of cane crushed in sugar factory. Pressmud is of two type i.e. sulphitation press mud and carbonation press mud cake (Rana *et al.*, 2003).The press mud, which made by sulphitation process, i.e. sulphitation press mud is good Source of nutrient and Amendment for saline alkaline soi1. The press mud which is made by carbonation process of sugar making i.e. carbonation press mud is use full source of nutrient supply and Amendment for acidic soil. Press Mud Cake has great potential to supply nutrient in addition to favorable effect on physical chemical and biological properties of soil during last three decades (Kumarswami *et al.*, 1995). PMCs have assumed greater importance in cane cultivation PMCs have been found beneficial in increasing the yield of sugarcane. An economy of 50-70 kg N/ha has been obtained by several worker in sugarcane - ratoon - ratoon cropping system by integrated use of PMCs and fertilizer N. PMCs have also increase nitrogen use efficiency by 4-8%. Sulphitation press mud (SPMC) found to be increasing organic carbon and availability of NPK and micronutrient in soil. The by-products of sugar factory like and press mud have been reported to be increasing the yield of sugarcane. Several researches have proved that factory waste like press mud has great potential in improve cane yield. Dantur *et al.* (1986) Studied with the using of filter press mud cake as nitrogen fertilizer that included it effect on sugarcane alone or in combination with urea. The result showed that the filter press mud cake was more efficient than urea, producing more cane. It was particularly effective in ratoon cane and in poor soils. Kanwar *et al.* (1937) observed that cv. CoJ 64 with two press mud cake and FYM, each @ 20 t/ha over applied alone or plus 100 kg N/ha or N at 150 Kg/ha applied alone the residual effect was studied with the ratoon crop which also received N at 115 Kg/ha. The best result with regard to yield and cane quality were obtained with sulphitation press mud cake (PMC) + N (69.7 t/ha) and with carbonation PMC + N (66.4) t/ha), the control yields in ratoon cane was 57.1 t/ha. Schndaliaris *et al.* (1990) reported from Argentina that sugarcane cv. TUG 67-21 (as a 1st ratoon crop in 1987

and 2nd ratoon crop in 1988 was given the equivalent of 90 kg N as filter press mud cake and urea, cane yield ranged from 24.5 t/ha without N to 42.6 t/ha with filter press mud cake. Average yield was 52.0 t with urea. Yield differences between application dates were small but yields tended to decrease with delayed application. Yaduvansi and Yadav (1990) reported that uptake of N by sugarcane at harvest increased significantly compared with control, with increasing rate of press mud and N application, it was lowest in the control and maximum where combined application of 150 kg and 30 t/ha press mud. Swamy *et al.* (1995) studied that integrated use of nitrogen fertilizer (0, 50, 75 and 100% of recommended doses) and press mud cake (0, 2, 4- and 6t /ha, or 4 t/ha + *Azotobacter* at 5 kg/ha) in sugarcane plant and ratoon. The quantity of nitrogen requirement to produce it can is higher for ratoon than for the plant crop. The contribution from fertilizers, press mud cakes and *Azetebactor* were higher in ratoon crop than the plant crop integrated use of (68 kg N + 4t press mud cake/ha gave an economy of 56 kg N/ha besides maintaining the yields of cane and sugar from ratoon crop.

7. Bio fertilizer in INMS

The Nitrogen balance studies using 15^N have provided direct evidences for N fixation taking place in sugarcane. Dobereiner (1961) reported first time bio1ogical nitrogen fixation taking place in sugarcane. Some of the species of *Azotobacter Azospirillum* and *Bacillus* have been reported to economics fertilizer N in sugarcane to the extent of 50% (Table 7). Onfarm trails conducted in Tamilnadu have indicated reduction in N dose by au dose by about 25% with the application of both *Azesprillum* and *Azotobacter*. Studies on the efficacy of biofertilizer in reducing the N dose in sugarcane under subtropical condition have revealed that there is no significant difference in the cane yield levels obtained in the central plant with 150 kg N/ha, 75% N with soaking sets in *Azesprillum*. It is observed that different isolation of *Azetobactor* has different capacity for N fixation. In Bihar an economy of 30-35' kg N/ha is obtained with *Azotobacter* application. Application of 5 kg/ha *Azotobacter* culture by root band method at planting of sugarcane in medium black soil increases the yield of sugarcane at padegoah in Maharashtra. The foregone discussion may lead to conclude that biofertilizer have promises for N economy in sugarcane farming.

New microorganism like *Acetobacter diazetrophicus* are found to be associated in large number in roots and stem of sugarcane and *Herbaspirillum seropedicae* is reported to associate on all parts of sugarcane viz., roots stems and leaves of Sugarcane. Swamy *et al* (1994) working at Anakapalle, Andhra Pradesh, on sugarcane cv. SA-261 was given 0, 112, 168 or 224 Kg N/ha, 0, 2, 4 or 8 ton press mud cake and 4 ton press mud cake + 5 Kg *Azotobactor* /ha. Cane yield increased with increases in N and press mud cake applications. Application of 68 kg N + 4 ton press mud cake + *Azotobacter* gave a similar yield to 224 kg N/ha + 4t press mud cake giving an economy of 56 kg N/ha. Patel *et al.* (1981) observed that application of 5kg/ha *Azotobacter* culture by root band method at planting of sugarcane in medium black soil had creased the yield of sugarcane at Padegoan in Maherashtra. The culture with 250kg N/ha gave an economy of 100kg N/ha by producing cane more or less equal to that with 350 kg N/ha (Table 8). Mishra *et al.* (1990) studied the effect of bio fertilizers and their method of application on economy with 2 cultivar viz., .Co 7711 and Co 1148 with 150 kg N and Bio fertilizer (*Azotobacter* and *Azospirillum*). The results are showed that 75% of N and application of any biofertilizer give cane yield equal to as 150 kg N so biofertilizer save 37.5 kg/ha. However reducing the N dose up to 51 % with biofertilizer application significantly reduced the cane yield and other growth and yields parameters like germination and tiller population at 90 days stages.

Table 7: Sugarcane varieties have been categorized based on their responses to bio fertilizer

Bio fertilizer	Responsive sugarcane varieties
Azospirillum	Co 1148, Co 7204 Co 7704, Co7717, Co 82808,Co 8209
Azotobacter	Co 853, Co 62157, Co 8148,Co 419, Co 740, Co 775
Azotobacter and Azospirillum	Co 449, Co 617, Co 975, Co 62174, Co 6304, Co7314, Co 7314, Co 7508 Co81122, Co 82215, Co 671

Table 8: Effect of *Azotobacter* application on cane yields (t1ha) and N economy in sugarcane at Padegoan in Maherashtra

N (kg/ha)	***Azotobacter* treatment**	
	Untreated	**Treated**
250	131	156
300	146	163
350	149	187
450	142	155
Mean	142	165
CD (P=0.05)	15.0	

CONCLUSION

Sugarcane ratoon has every right for proper care for achieving its potential level. Along with other factor influencing the performance of ratoon cane, balance nutrition is one major aspect, which can be successfully done by conjunctive use of all the available resources in a sustainable manner. INMS advocates the uses of high analysis chemical fertilizers, inclusion of legume and other crops in cropping system. In this system f legume is also utilized as a green manure and as inter crop. Organic manure and crop residue are excellent source of various major and micro nutrients, incorporation of factory waste, and recently developed bio fertilizer. INMS fine tuned with nature i.e. ecology of region / locality, which will decently having longevity over any single source be it chemical or organic.

REFERENCES

Acosta A, Reuez R and Papet H. 1985. Influence of nitrogen on increasing sugarcane production in Red and Yellow. *Ferralitic soil. Bulletin INICA* - No.1: pp 41-52.

Agarwal ML, Dixit RS, Gupta DN, Bhardwaj NM and Singh NP. 1974. Sugarcane varieties in Central and Rohilkhand ranges of U.P. and their performance under various agro-c1imatic conditions. *Proc. Sug. Techno. Ass. India* **40** (2): 11-31.

Bhutada, J.C., and Parshar, K.S. 1951. Studies on the effect of intercropping and nitrogen fertilization on the yield and quality of sugarcane first ratoon . *Indian Sugar*. 31 (4): 273-279.

Chauhan RS, Yadav R.L and Bajpai KK.1991. Effect of N application with or without manganese on yield of ratoon cane. *Bharatiya Sugar* **16** (4): 59-60.

DAC.2015. Department of Agriculture and cooperation, Ministry of Agriculture, Government of India 4th Advance Estimate (2014-15) released on 17/8/2015.

Dantur NC, Scndaliaris J, Roncedo M and Alonson J. 1986. Effect of filter press cake as an nitrogen fertilizer on sugarcane. *Revista Industrial-Y- Agricola De. Tucuman*. **63**(2): 29-43.

Devaraj G, Kadirvel AK and Rajan SD. 1973. Co 6304: A new sugarcane variety for high yield and quality. *Cane Grow. Bull*. **1** (4): 11 -12.

Durai R. 1991. How to get high yield from ratoon sugarcane. *Indian Farming* **41** (5): 33-34.

Golden EL.1982. Effect of fertilizer P and S on sugarcane yield and leaf nutrient content. *Better Crop with plant food* for winter. 22-23.

Gotera EP, Tappy RM, Araneta MO and Espada WG.1980. Fertilizer management in sugarcane ratoon. *In sevententh cong. of Int. Soci. of Sugarcane Tech.* Vol. I-256 – 260.

ICAR. 2006. Hand Book of Agriculture. Indian Council of Agricultural Research, New Delhi. India.

Juang TC, Kao MM and Chang CH.1979. The effect of zinc application on yield and nutrient uptake of sugarcane. *Sugar J*. **42** (5): 25-29.

Kanwar RS, Jatinder, Kapur and Kapur J. 1977. Direct and residual effect of sulphitation and carbonation press mud cake on the yield and quality and nutrition of sugarcane. *Indian Sugar Crop. J.* **13** (4) : 1-5.

Kumar Alok, Tripathi HP and Yadav DS. 2007. Correcting nutrient imbalance for sustainable crop production. *Indian J. Fertilizers*. **2** (11):37-44.

Kumarswami K and Rajasekaran S. 1993. Response of sugarcane crop to phosphorus as influence by time of application. *Sugar J*. **43** (4): 233-235.

Kumarswami K and Rajasekaran S. 1994. Response of sugarcane to nitrogen, phosphorus and bio fertilizers. *Cooperative Sugar* **26** (2): 101-103.

Kumarswami K, Jamuna P, Rao KV, Satyanarayana Y and Rao TKVVM. 1995. Integrated use of press mud cake and fertilizer nitrogen in sugarcane plant and raotoon cropping system. *Cooperative Sugar* **26**(9): 449-453.

Mane VS and Salunkhe CD. 1978. Studies on sugarcane ratoon. *Indian Sugar* **28** (7):441-444.

Parasar SK and Prasad A. 1985. Studies on various intercropping and management Practices on yield attributes, yield and juice quality of first sugarcane ratoon. *Indian Sugar*. **35** (2): 121-125.

Patel HS, Naik PL, Patel MP and Mehta NJ.1993. Phosphorus nutrition under continuous cropping system of sugarcane. *Indian Sugar* **43** (9): 699-703.

Pereira RR, de Faria CMB and Margada LB. 1995. Effect of phosphorus application rates and its residual effect on the yield of sugarcane on vartisol. *Pesquisa Agropecuaria Brasilira.* **30** (1): 43-48.

Raghuraj, Singh OP Gupta and SK Patel. 2015. Energy Use Pattern and Scenario Change in Sugarcane (ratoon) Cultivation for Bhabar Region of Uttarakhand, India**.** *Journal of AgriSearch* **2** (2): 242-245.

Rana NS and Singh AK. 2003. Nitrogen dynamics in sugarcane ratoon as Influenced by residue management and nitrogen fertilization. *J. Farm. Syst. Res. Devlp.* **8** (1): 37-39.

Rana NS, Singh AK and Tomar TPS. 2002. Juice quality and sugar yield in sugarcane ratoon as influenced by trash mulching and nitrogen levels. *Ann. Agric. Res*. **23** (3): 419-421.

Rana NS, Singh AK, Kumar Sanjay and Kumar Sandeep. 2003. Effect of trash mulching and nitrogen application on growth yield and quality of sugarcane ratoon. *Indian J. Agron.* **48** (2): 124-126.

Rathi KS and Singh RA. 1982. Net income and quality of juice of cane ratoon as affected by increasing doses of nitrogen. *Indian Sugar*. **32**(1): 11-14.

Rathi KS and Singh RA.1979. Effect of companion cropping sequences on the yield and quality of sugarcane ratoon. *Indian Sugar*. **29** (1): 15-18.

Said R, Ghulam B, Shah Nazar, Rahman S, Sarwar G and S Nazar.1990. Varital response of sugarcane to different doses of potash. *Sarhad J.Agric.* **6**(2):175-178.

Shinde DB, Navale AM and Jadhav SB.1993. A study on incorporation of sugarcane trash in ratoon sugar. *J. Maha. Agric. Univ*. **1** (2): 264-265.

Singh AK, Manibhushan, Chandra Naresh and Bharati RC. 2008. Suitable crop varieties for limited irrigated conditions in different agro climatic zones of India. *Int. J. Trop. Agri*. **26** (3-4): 491-496.

Singh AK, PK Sundaram and Verma Nidhi. 2012a. Harnessing production potential of dry land agriculture through efficient nutrient management (ENM) under climate change condition. *Prog Agri.* **12** (2):229-240.

Singh AK, Singh D, Singh AK, Gade RM and Sangle UR. 2012b. Good Agronomic Practices (GAP) - An efficient and eco-friendly tool for sustainable management of plant diseases under changing climate scenario. *J. Plant Disease Sci.* **7** (1):1-8.

Singh GB and Singh DV. 1992. Integrated nutrient supply system in sugarcane based cropping system. *Ferti News*. **37**(4): 15-22.

Singh GB. 2006. *Sugarcane and Sugar beet*. In Handbook of Agriculture ICAR publication. 1002-1017.

Suryani A and Rasjid A. 1994. The effect of sowing date of intercropping moong bean of first ratoon yield of sugarcane cv. PS 58 on alluvial irrigated soil at pasuran. *Majalah- Perusahan Gula* **30**(2): 25-31.

Willey RW. 1990. Resource use in intercropping system. *Agric. Water Management*. **17**:25-31.

Yadav RL. 1983. Yield and quality of sugarcane ratoon as influenced by residual and direct nitrogen application. *Indian Sug. Crop J*. **9**(3): 15-17.

Yadav DV. 1994. Response behaviors of sugarcane to NPKS and micronutrient in different part of country. *Fert. News*. **38**(10): 31-33.

Yadav RL, Kumar Rand Verma RS.1990. Effect of nitrogen applied through new carries on yield and quality of sugarcane. *J of Agric. Sci*. **114**(2): 225-230.

Yadav RL.1989. Long term effects of manures and fertilizers on sugarcane based cropping system. *Fertil. News.* **34**(4):53-59.

Zambello E, Junior HP, Orlande Hagg and Filho J. 1980. Application of diagnosis and recommendation integrates system DRIS to different soil and time of foliar sampling in ratoon sugarcane. *Anais do Escola Escola Supriorde Agriculura Luize de duelroz*. **37**: 241-289.

Citation

Singh AK, Bharati RC, Chandra N and Dimree S. 2015. Integrated Nutrient Management System: Smart way to improve cane production from sugarcane ratoon. *Journal of AgriSearch* **2** (4): 233-243.