

Review Article

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## A Review on Effect of INM on Sugarcane Growth, Yield and Quality

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### ABSTRACT

#### Keywords

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Integrated nutrient management programme is unavoidable for achieving sustainable sugarcane production along with quality of sugarcane. Application of organic nutrient sources viz., farmyard manure, cane trash, pressmud, vermicompost, biomethanated distillery effluent, biogas slurry, biocompost and biofertilizers along with inorganic sources of nutrients in combination have recorded increased cane yield over only inorganic fertilizer application, in addition to improvement in soil fertility and reducing the cost of cane production. Intercropping and incorporation of green manures have established beneficial effects in improving sugarcane productivity in conjunction with higher nutrient use efficiency. Nitrogen fixing biofertilizers are useful in economizing the increment in cane yield. Integration of organics and inorganics in 1:1 ratio leads to saving of 50% inorganics and increase in yield upto 21%.

### Introduction

Sugarcane (*Saccharum spp.* complex hybrid) is an important cash crop of India. Sugar industry is the 2<sup>nd</sup> largest agro-based industry in India and contributes significantly to the socio-economic development of the nation. Indian sugar industry is also a major sector to create employment, probably 7.5% per cent in Indian economy and plays a leading role in global market being the world's 2<sup>nd</sup> largest producer after Brazil, producing nearly 15 and 25 % of global sugar and sugarcane respectively. Sugar industry is the source of

livelihood for 50 million farmers and their families. It provides direct employment to over 5 lakh skilled and semi-skilled labours in sugar mills and allied industries across the nation (Venkatesh and Venkateswarlu, 2017).

The economic part of sugarcane is the stalk where sucrose is accumulated from which sugar is prepared. Sugarcane crop and its products contribute about 1.1% to the national GDP which is significant considering that the crop is grown only in 3% of the gross cropped area. The contribution of sugarcane to the agricultural GDP has steadily increased from

about 5% in 1990–1991 to 10% in 2010–2011. During the last two decades, the average annual growth of sugarcane agriculture sector was about 2.6% as against overall growth of 3% in agriculture sector in the country (Solomon, 2015).

With per capita consumption of white sugar at 22 kg annum<sup>-1</sup>, and the estimated population of 1.50 billion by 2030 AD., the consumption of white sugar may be increased to 33 million tonnes. It is estimated that by 2030 AD., about 520 million tonnes of sugarcane with average sugar recovery of 10.75 per cent (60 per cent cane will be utilized for white sugar, and 15 per cent will go for ethanol production) will be required. This will entail a productivity requirement of 100-110 t ha<sup>-1</sup>, since the area under sugarcane cultivation may stabilize around 5.00 mha (IISR, 2011).

The exploding population and its demand for food, fiber and energy which is increasing every year needs to be fulfilled sustainably. This can be achieved only by increasing the vertical productivity of plants in consideration, since the area cannot be increased. This increase in production not only calls for management of plants but also the soil since the soil is losing its fertility day by day. Therefore a holistic approach is required to not only increase the yield per hectare of plants but also to maintain the deteriorating soil health. The options available to us are not limited but we need to use it judiciously. Organic manures apart from acting as a source of nutrients also improve soil health by improving the soil biodiversity, microbial population as well as improvement of soil physical and chemical property. Use of organic manure either singly or in combination with chemical fertilizers will sustain the soil fertility or improve the soil health.

The unsustainability of Chemical-driven

agricultural practices have led decline in the crop productivity as well as hamper the soil fertility. This necessitates the use of alternative sources of plant nutrients which not only improves soil health but can also improve and sustain productivity of sugarcane. Majority of these sources are easily accessible to the farmers and therefore also reduces the cost of cultivation thereby improving the income level of farmers. Use of organic sources of nutrients either alone or in combination with chemical fertilizer pertains to eco-friendly practices which lead to a holistic management of soil-crop system. The alternative to chemical driven farming is organic farming which promotes and improves the health of agro ecosystem related to biodiversity, nutrient biocycles, soil microbial and bio-chemical activities (Chogatapur *et al.*, 2017). Organic farming emphasizes largely on use of different organic manures (bulky and concentrated) along with practices such as green manuring, use of biofertilizers and biopesticides. It also emphasizes on use of various cultural practices along with botanicals for managing pest and diseases.

The practice of organic farming depends upon the nature and source of plant nutrients, understanding the practices which are situation specific. India ranks 9<sup>th</sup> in terms of land under organic cultivation and 1<sup>st</sup> in terms of total number of organic producers (IFOAM Year Book, 2018). In India, the total area under organic farming is 3.56 mha from which 1.70 mMT of certified organic products were produced including all varieties of food products *viz.*, oilseeds, sugarcane, cereals and millets, cotton, pulses, medicinal plants, tea, fruits, vegetables etc. The export of organic products also earns handsome revenue to the state. The organic food export realization for 2017-18 was around INR 3453.48 crore (Apeda, 2018).

## **Nutrient Management and its effect on Sugarcane**

A cane yield of 100 t ha<sup>-1</sup> may remove 205 kg N, 55 kg P, 275 kg K, 30 kg S, 3.5 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from the soil besides the losses of nutrients during cropping season (Kumar and Chand, 2009). This necessitates the use of organic manures, which is a reservoir of nutrients (macro and micro) for improving the sustainable productivity of sugarcane. Various organic sources of plant nutrients like farmyard manure (FYM), oil cakes, press mud cake, vermicompost, green manure, legume as intercrops and sugarcane trash are being explored for use as sources of nutrients since ages. Addition of organic amendments represents an important strategy to protect agricultural lands from excessive soil resource exploitation and to maintain soil fertility.

India being the largest sugarcane cultivar in world generates huge amount of wastes as by product of cane plantation as well as sugar production. Recycling of sugar industry wastes can be gainfully utilized to enhance sugar productivity and reduce the cost of cane production.

Organic sources of nutrients not only help in supplementing the nutrients to sugarcane but also maintain favorable physical, chemical and biological soil environment. Long term fertilizer experiments have indicated the need for basal application of FYM for maintaining optimum fertility status. Sugarcane trash is the chiefly available organic waste in cane growing areas accounting for 10-12 % of the cane weight. Press mud and distillery effluent being an important waste material of sugar industry can be used as such or as biocompost after their decomposition with the help of microbes. The works of different people throughout the world on organic sources of nutrients concludes that it not only supplies plant nutrients throughout the growing phase of sugarcane but also improves the physical,

chemical and biological characteristics of soil. The use of bio-fertilizer in addition to organic manures improves the availability of nutrients in soil determining the growth and yield of crop. Also, the incorporation of organic materials along with fertilizer-N affects the amount and distribution of organic N-fraction viz. exchangeable NH<sub>4</sub><sup>+</sup>-N, hydrolysable NH<sub>4</sub><sup>+</sup>-N, hexoseamine-N, amino acid-N, unidentified-N and status of total-N (Santhy *et al.*, 1998) and carbon pool considerably in soil (Sinha *et al.*, 2017).

## **Effect of organic manures on growth and yield attributing characters of sugarcane**

Kathiresan *et al.*, (1993) observed significantly higher number of shoots with the combined application of neem coated urea (210 kg N ha<sup>-1</sup>), press mud (25 t ha<sup>-1</sup>) and phosphobacteria (10 kg ha<sup>-1</sup>) + *Azospirillum* (10 kg ha<sup>-1</sup>). Navale *et al.*, (1995) reported significant improvement in germination, tillering, number of millable canes, and girth and height of cane in *Azospirillum* + *Azotobacter* treatment with fertilizer N along with saving of 25-50 kg ha<sup>-1</sup> fertilizer-N. Among the green manures incorporated, *Crotalaria juncea* recorded highest number of millable canes followed by *Sesbania aculeata* (Kathiresan and Manoharan, 1999). Roodagi *et al.*, (2000) reported maximum tiller count with sugarcane + sunnhemp (as green manure crop) compared to sugarcane sole crop. Shankaraiah *et al.*, (2001) carried out research at Mandya, Karnataka and reported that application of SSP and press mud on equal P basis along with phosphate solubilizing bacteria improved leaf area index (LAI), length and weight of stalk. Patel (2002) revealed that application of trash mulch (@ 10 t ha<sup>-1</sup>) and FYM (@ 25 t ha<sup>-1</sup>) significantly improved single cane weight which is directly related to cane yield. Sharma *et al.*, (2005) reported that integration of FYM with fertilizers in 1:1 ratio was found better with respect to increased shoot population due to

blending of organic and inorganic nutrient sources in equal ratio (50:50) leading to saving of 50% inorganics. Inoculation of sugarcane with *Gluconacetobacter diazotrophicus* improved germination, plant population and plant height due to release of growth promoting substances in addition to increased uptake of nutrients (Suman *et al.*, 2005). Singh *et al.*, (2007) recorded highest number of millable canes, longest and thickest canes with addition of press mud (@ 10 t ha<sup>-1</sup>).

The integrated application of by nutrients with 75 per cent recommended inorganics + press mud (@ 20 t ha<sup>-1</sup>) + rice mill husk (@ 10 t ha<sup>-1</sup>) gave higher number of millable canes, cane height and girth (Paul and Mannan, 2007). Yadahalli (2008) found that application of neem cake helped for significantly higher germination percentage (68.5%) than other amendments. There was a significant improvement in number, length and girth of millable canes, number of nodes and length of internodes with the combination of organic and inorganic plant nutrient sources along with biofertilizers as reported by Kanjana and Pitchai (2009). Jamuna and Paneerselvam (2014) found maximum millable cane population with the application of *Gluconacetobacter diazotrophicus* (@ 10 kg ha<sup>-1</sup>) + AM fungi (@ 25 kg ha<sup>-1</sup>) + *Azophos* (@ 10 kg ha<sup>-1</sup>) + 75 per cent RDF. Integration of press mud, sugarcane trash and micronutrient Fe recorded significantly higher number of tillers, and number, length and weight of millable canes over RDF (Jha *et al.*, 2017). Umesh *et al.*, (2018) concluded that number of tillers and millable canes increased significantly at higher level of N when applied with organic manure whereas the effect of biogas slurry was found more pronounced.

### **Effect of organic manures on yield of sugarcane**

Sonawane and Sabale (2000) found higher

cane and sugar yield on application of 250 kg nitrogen through urea and 50 kg N through press mud showed positive response with respect to cane yield and trash yield. Shankaraiah and Hunsigi (2000) reported that soil inoculation of nitrogen fixers *viz.*, *Azotobacter* in plant crop and *Azospirillum* in ratoon crop increased cane yield by 10-15 % and *Agrobacterium radiobacter* and *Bacillus megaterium* in plant crop and *Aspergillus awamori* and *Bacillus megaterium* in ratoon crop exhibited 8-10 per cent higher cane yield as a result of perceptible improvement in various growth and yield parameters. Bokhtiar *et al.*, (2001) observed 20-30 per cent in plot receiving press mud (@20 t ha<sup>-1</sup>) along with fertilizer N over RDF. Inoculation of combined culture of *Azotobacter* + *Azospirillum* or *Acetobacter* + P-solubilizing bacteria with 75 per cent of N and P along with full dose of K gave 30 per cent higher cane yield than uninoculated control as observed by Lokhande and Ghatge (2001). Manickam *et al.*, (2002) reported higher cane and sugar yield in plots receiving 100 per cent NPK + sunnhemp over RDF. Shankaraiah and Nagaraju (2002) established that soil inoculation with *Azotobacter chroococcum* and *Azospirillum brasiliense* (@ 2.5 kg ha<sup>-1</sup> each) gave higher jiggery yield in both plant and ratoon crop. Durai and Devaraj (2003) reported higher cane and sugar yield with application of FYM + 100 % NPK + *Azospirillum* whereas Kathiresan (2004) reported higher cane and sugar yield with application of 75% RDN + soil inoculation of *Azospirillum* and *Azotobacter*. Integrated use of enriched press mud (@ 15 t ha<sup>-1</sup>) at recommended fertilization resulted in increased cane and sugar yield to the tune of 21 per cent over RDF (Shankaraiah and Kalyanmurthy, 2005). Hari and Srinivasan (2005) observed that *Azospirillum* under lower nitrogen level significantly improved cane and sugar yield over *Gluconacetobacter*, *Azotobacter* and uninoculated control. Saini *et*

*al.*, (2006) reported that press mud cake (@ 10 t ha<sup>-1</sup>) + fly ash (@ 10 t ha<sup>-1</sup>) + PSB along with 75 per cent RDF significantly improved cane and sugar yield over chemical fertilizers alone. Chauhan *et al.*, (2008) observed that highest cane yield was achieved in the treatment receiving N through bio-compost and inorganic source (50:50) on equal N basis followed by 33 per cent N through bio-compost + 67 per cent through inorganic fertilizer. Srivastava *et al.*, (2008) reported highest cane yield with sulphitation press mud (@ 10 t ha<sup>-1</sup>) + FYM (@ 10 t ha<sup>-1</sup>) in autumn and spring planted sugarcane crop. Trash burning along with incorporation of *Sesbania aculeata* gave 50.6 and 17.7 per cent increase in ratoon cane yield over trash removal and

trash burning treatments respectively (Chandra *et al.*, 2008). Integration of FYM at 25 per cent RDN with fertilizers and biofertilizers to plant crop and trash incorporation (@ 10 t ha<sup>-1</sup>) to ratoon crop increased cane yield (Virdia *et al.*, 2009). Rani *et al.*, (2011) revealed that 50 per cent reduction of inorganic fertilizer with oil cakes in plant cane and addition of 50 per cent more N with same amount of fertilizer for ratoon crop improved cane and sugar yield. FYM + RDF registered higher cane yield over only RDF as elucidated by Lakshmi *et al.*, (2011). Singh *et al.*, (2014) established that cane yield increased significantly due to integrated use of inorganic + organic fertilizer along with dual biofertilizers (*Azotobacter* + PSB).

**Table.1** Effect of different organic manures on productivity of sugarcane

Organic manures	Cane yield (t ha <sup>-1</sup> )				References
	Without organic manures	With organic manures	Increase / decrease		
			(t ha <sup>-1</sup> )	(%)	
<i>Sesbania aculeate</i>	104.9	144.5	39.6	37.75	Chandra <i>et al.</i> , 2008
Vermicompost	87.42	93.88	6.46	7.38	Lakshmi <i>et al.</i> , 2011
Sugarcane trash	47.0	59.3	12.3	26.17	Umesh <i>et al.</i> , 2013
Biomethanated distillery effluent	58.50	72.13	13.63	23.29	Sinha <i>et al.</i> , 2014
Biocompost	58.70	74.14	15.44	26.30	Sinha <i>et al.</i> , 2017
Biogas slurry	57.0	70.2	13.2	23.15	Umesh <i>et al.</i> , 2018

Cane yield increased significantly with the application of BMDE, bio-compost and FYM over control (Sinha *et al.*, 2014). Bhanuvally *et al.*, (2017) concluded that application of 125 per cent N through either neem or sulphur or coal tar coated urea improved cane yield significantly by increasing nitrogen use efficiency and by reducing the nitrogen losses. Srivastava *et al.*, (2018) observed increase in ratoon crop yield from fifth to ninth ratoon crop due to addition of bio-manures over RDF.

**Effect of organic manures on quality of sugarcane**

Sonawane and Sabale (2000) reported that application of 250 kg nitrogen through urea and 50 kg N through press mud showed positive response with respect to brix, pol, CCS per cent and sugar yield. Shankaraiah and Nagaraju (2002) revealed that soil inoculation of *Azospirillum brasilense* @ 2.5 kg ha<sup>-1</sup> resulted in improvement of the sucrose content in jaggery with parallel reduction in the level of reducing sugar both in plant and

ratoon crop. Jeyaramana and Alagudurai (2003) found that application of 275:62.5:112.5 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per hectare with daincha as an intercrop and its incorporation at 60 days after planting along with soil application of phosphobacteria (@ 10 kg ha<sup>-1</sup>) at the time of planting setts recorded higher brix, pol, purity and CCS in sugarcane juice. Application of PMC (@10 t ha<sup>-1</sup>) coupled with biofertilizers (PSB) at 2.5 kg improved the quality of sugarcane compared to recommended NPK alone observed by Saini *et al.*, (2006).

Venkatakrishnan and Ravichandran (2007) reported that application of press mud significantly improved juice quality of sugarcane with higher value of brix and pol percentage in plots treated with press mud @ 25 t ha<sup>-1</sup>. Vedprakash *et al.*, (2009) observed that application of FYM, ground nut cake and inorganic nitrogen in the ratio of 1:1:1 proved better with regards to cane yield but without alteration in juice quality.

Thakur *et al.*, (2012) reported that cane juice quality *viz.*, brix, sucrose and purity content remains unaffected under organic and conventional farming system. Sinha *et al.*, (2014) revealed that the quality of juice, *viz.*, sucrose and purity remains unaffected due to INM. Kumar *et al.*, (2015) observed trash mulching @ 10 t ha<sup>-1</sup> significantly improved brix, pol and CCS% of cane juice over control. Umesh *et al.*, (2018) established that the juice quality significantly enhanced at higher N level in conjoint with BGS.

Conclusion of the study is as follows:

In order to maintain the sugarcane productivity of sugarcane at a higher level on a long-term basis it is indispensable to evolve a system whereby integration of nutrients from all the available sources should be utilized keeping in mind the soil health

benefits. Also, maintenance of sugarcane production under intensive cropping requires that organic carbon content of the soil must be retained either by the recycling of organic farm wastes or by the use of organic sources. Growing of green manure in the inter row spacing and incorporation at appropriate time not only supplement the fertilizer but also maintain the soil fertility and sustain the cane yield. Findings of different authors confirm that there is saving of N upto 25% when green manures were raised as intercrop in sugarcane. Inoculation of biofertilizers like *Azospirillum*, *Azotobacter*, *Glucoacetobacter*, *Bacillus*, *Pseudomonas* and *Aspergillus* improves the nitrogen and phosphorus content of soil and leads to a saving of 20-25% of inorganic fertilizers. It leads to 20-50% economy in fertilizer nutrients besides soil sustainability. A judicious conjugation of organic and inorganic sources in addition to biofertilizers is a prospective tool for maintaining the cane productivity as well as improving soil fertility in sugarcane and sugarcane based cropping systems.

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