

Soil incorporation of trash and foliar application of plant growth regulators boosted sugarcane ratoon yield

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Sugarcane (Saccharum spp.) is a major agro-industrial crop of sub-tropics covering approximately 5.06 million ha in India with an average productivity of 60 tonne ha⁻¹. In south Asia, ratoon crop covers approximately 50 % of total cultivated area. The ratoon is the regenerated crop plant from the germinating bud of the stubble from the previous crop. Ratooning practice saves cost on preparatory tillage and planting material and benefits from the residual manure and moisture. Besides, the ratoon sugarcane matures earlier than the newly planted sugarcane (plant sugarcane). Well established subterranean buds, supporting root system and the biologically active cane stubbles contribute towards early growth and maturity of ratoon crop but yields are generally found to be lower than plant crop. However, there is a decline in the yield of ratoon sugarcane in the successive years under normal conditions. The probable reasons for lower average ratoon yields include decline in cane-stubble population low availability of nutrients and moisture owing to soil compaction and poor soil organic carbon. Usage of trash generated from the plant crop of sugarcane lessens than soil compaction and improves the availability of nutrients and moisture that supports the initial growth of the ratoon crop. Later application of PGRs at various growth stages further mitigates the adverse effects of tiller mortality and poor assimilate accumulation and partitioning towards stalk. Degradation of trash of previous plant crop and usage of PGRs offered improved rhizospheric environment for below and above ground growth leading to increased ratoon yield.

Key words: Growth regulator, Soil, Sugarcane

Sugarcane ratoon occupies more than 50% of the total sugarcane area in the country. However, its contribution to the total cane production is about 25-30%. Productivity of ratoon crop is 10 to 30% less than the plant crop of sugarcane. Ratoon productivity thus has a significant role in governing the overall sugarcane productivity. The prime reason for poor productivity of ratoon crops is low and differential ratooning potential of cultivars and reduction in physiological efficiency due to several abiotic stresses *vis-a-vis* low or excess availability of water or high or low temperatures during crop growth cycle. Other reasons for low yield of this crop include formation of toxic substances in the



Fig 1. Sugarcane trash heap in field after harvest of plant crop

rhizosphere, low nutrient uptake ability of ratoon, depletion of soil nutrients, shallow ratooning, soil

compaction and increased incidence of pests and diseases. These stresses affect the average, cane height,



Fig 2. Sugarcane trash burnt by farmers in field

intermodal length, cane weight and tiller survival adversely.

Status and composition of sugarcane trash

Sugarcane plant crop from which ratoon crop is initiated generates approximately 131.9 metric tonne of trash annually, which contains approximately 0.660 metric tonne nitrogen, 0.198 metric tonne phosphorus and 0.752 metric tonne potassium. Water soluble substances in trash range between 14 and 18% on dry weight basis and has 33 kg/metric tonne of phenolic acid (Fig. 1). The carbon and ash contents in trash decreases by 8% and 53% indicating that half the nutrients present in trash are released without microbial decomposition. Being a rich nutrient reservoir, trash helps to maintain the soil fertility by adding nutrients, conserving moisture and improving soil microbial diversity and their activities, soil enzymes, improving nutrient uptakes and sustains soil quality with minimum use of energy, intensive inputs like irrigation and chemical fertilizers.

Along with, its mulching in soil, renders the maintenance of soil temperatures, soil moisture and aggregate and keeps weeds under check. Trash burning of sugarcane in field results in loss of entire amount of C, approximately 80–90% N, 25% of P, 20% of K and 50% of sulphur in form of various gaseous and particulate matters (Fig. 2). Burning

of sugarcane trash in field leads to loss of 1.03 metric tonne nutrient/year out of which 0.48 metric tonne is nitrogen, 0.017 metric tonne potassium and 0.37 metric tonne is phosphorus. Burning also loses out soil enzyme activities, microbial

diversities, reduces their functional potentials impacting the nutrient availability and their uptakes by the plants adversely. The status of sugarcane trash burnt in India is given in Fig 3.

Growing ratoon crop costs less than plant crop to farmers and is also advantageous to sugar mills since it fits into the crushing schedule, due to its early maturity immediately after crushing of early maturing varieties. Achieving high-yielding ratoon crop is therefore a valuable objective and the present study attempted combined utilization of sugarcane trash and plant growth hormones (Ethrel and Gibberellic acid) for enriching the below ground ratoon soil rhizosphere and improving above ground growth and development through usage of PGRs respectively. Sugarcane trash was mulched in ratoon soils through *in-situ* incorporation with pusa-compost-inoculants across the growth cycle while plant numbers, internodal length, their numbers and average

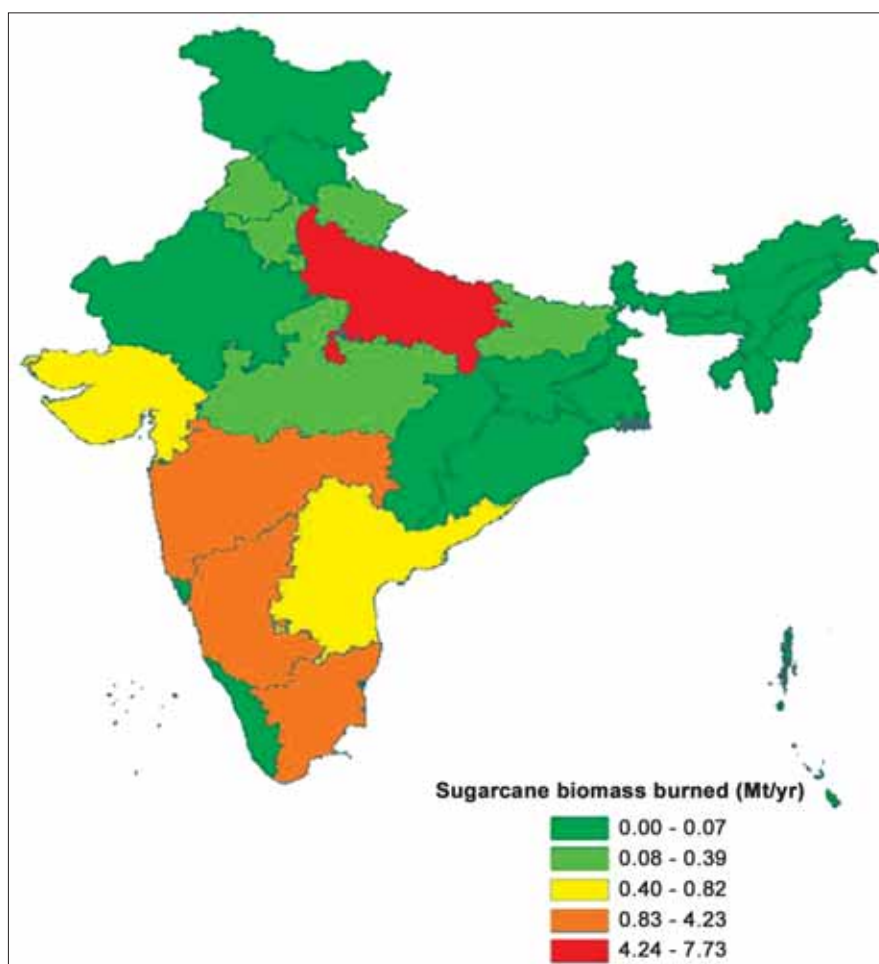


Fig 3. Distribution of sugarcane trash burnt in India



Fig 4. Sugarcane stubble bud sprouting after spread of trash (right) and without trash (left)

cane weight, were addressed through spray of *Ethrel* (6 @100 ppm) at 60 days after initiation (DAI), later followed by spray of GA_3 (@35 ppm) at 90, 120 and 150 DAI. The pusa-compost-inoculant contained *Aspergillus nidulans* / *Trichoderma viridae* / *Phenerocean cryzoporium* and *Aspergillus avamori*. The inoculants were sprayed on surface of trash and irrigated after 60 days followed up by turning it upside down for growth of microbes, aiding its spread in the entire trash for quick incorporation after its mineralization into soil. The inoculants helped in lignocellulosic decomposition of trash in lesser time. The trash from sugarcane was spread @ 12 tonne ha^{-1} before initiation of ratoon cane.

Effect of *in situ* incorporation of trash and ethrel spray on stubble bud sprouting

The ratoon crop gets initiated with sprouting of stubble buds and formation of tillers which is supported by the robust root system that was earlier attached with plant cane. The roots provide quick support to the underground buds. Despite such an established root system, sprouting is not only delayed due to low temperatures but also only 30 to 40% of stubble buds sprout. There is an urgency to initiate early and enhanced sprouting of stubble buds. *In-situ* incorporation of trash with pusa-compost- inoculants improved the sprouting of stubble buds by about 25% at 60 days after initiation (Fig. 4). Since the target of the present work is to have maximum stubble bud sprouting (80-90%), spray of *Ethrel* (@100 ppm) at 60 DAI rendered

increase in sprouting of the rest of the underground quiescent buds. This led to about 82% of sprouting and established an initial settling population of 90,000 settlings ha^{-1} against control (62,000 settlings ha^{-1}) at 90 days after planting.

The aim behind increasing the settling numbers at initial stage was based on finding of our earlier experiments with plant crops where we established that a higher initial settling population at 90 days after planting contributes about 45% to

the formation of NMC at harvest stage. The increase in initial settling population is due *in situ* incorporation of trash before initiation of ratoon which conserved more water and helped the underground bud sprout easily. Along with trash incorporation enriched the ratoon soil with carbon, nitrogen, phosphorus, zinc, copper, iron and manganese and helped in build-up of microbes in rhizosphere with enhanced phytosiderophores released by roots. Also as trash contributes about 0.4% N, the extra application of nitrogen (25 $kg\ ha^{-1}$) in ratoon crops as per general recommendations will get reduced by about 10-12 $kg\ ha^{-1}$ and minimize urea requirement.

Effect of *in situ* incorporation of trash and ethrel spray on tiller numbers and leaf characteristics

In situ incorporation of trash and *Ethrel* spray at 60 days after initiation caused significant improvement in tiller numbers and caused significant improvement in leaf development of the tillers (Figs. 5 and 6).



Fig 5. Pusa compost inoculant induced decomposition of sugarcane trash (left) and control (right)



Fig 6. Increased tiller numbers with Pusa compost inoculant and PGR application (right) and control (left)



Fig 7. Maximum tiller numbers in control (left) and with *Pusa compost inoculant* and PGR application (right)

Increase in leaf area increased the early canopy coverage rendering faster utilization of radiations for increasing the photosynthetic efficiency of the plants. The large tiller population was supported with improved nutrients, water and space availability respectively through trash decomposition and *Ethrel* application which led significant changes in leaf angle changed to 25° to 30° from 60 to 70°. This architectural change increased the space between the plants and R:FR ratio. This improved radiation use efficiency and turned the lower leaves more active photosynthetically, increasing the growth and development of tillers horizontally.

Effect of foliar spray of gibberellic acid on crop growth and stalk elongation

Once the tiller numbers were

obtained as expected, foliar application of GA₃ was done at 90, 120 and 150 days after initiation for further horizontal and vertical growth. The application led to significant improvement in horizontal and vertical growth of plants. There was marked improvement in plant and foliage numbers, leaf area index, specific leaf area, relative growth rate and net assimilation rate. There was increase in leaf area duration, biomass duration and leaf sheath length. These changes led to significant increase in internodal numbers, length and weight impacting the average stalk length and stalk weight. The PGR application sustained the increased tiller numbers due to presence of higher foliage numbers at longer distances which increased the R:FR ratio, improved the assimilatory apparatus development

and prevented their mortality (Fig. 7). The reduction in mortality of tillers is also supported by significant decline in production of ethylene which prevented the damage of protein-lipid –protein layer of plasma membrane of cells of tillers.

Increase in leaf area index enhanced photosynthetic activity and assimilate production in leaves. This increased source activity led to increased internodal demand for assimilates for preventing its over production. The enhanced sink demand is fulfilled by unloading of assimilates from leaves into internodes through elongated leaf sheath. The translocated assimilates into internodes are utilized in cell division, cell elongation and internodal elongation. The enhanced assimilate translocation from leaf phloem to internodes thus increased internodal numbers, internodal length, and internodal girth and stalk length against control (Fig. 8).

The changes induced through *in-situ* incorporation of trash and use of plant growth regulators led to a Tmax of 6.73 litre ha⁻¹ with minimum tiller mortality (54.5%). At harvest stage, NMC of 3.06 lakh / ha, with average cane weight of 598 g and cane yield of 183.15 tonne/ha was recorded against tiller mortality of 68.7%, NMC of 1.56 litre ha⁻¹, with average cane weight of 501 g and cane yield of 78.38 tonne ha⁻¹ in control. Over all *in-situ* incorporation

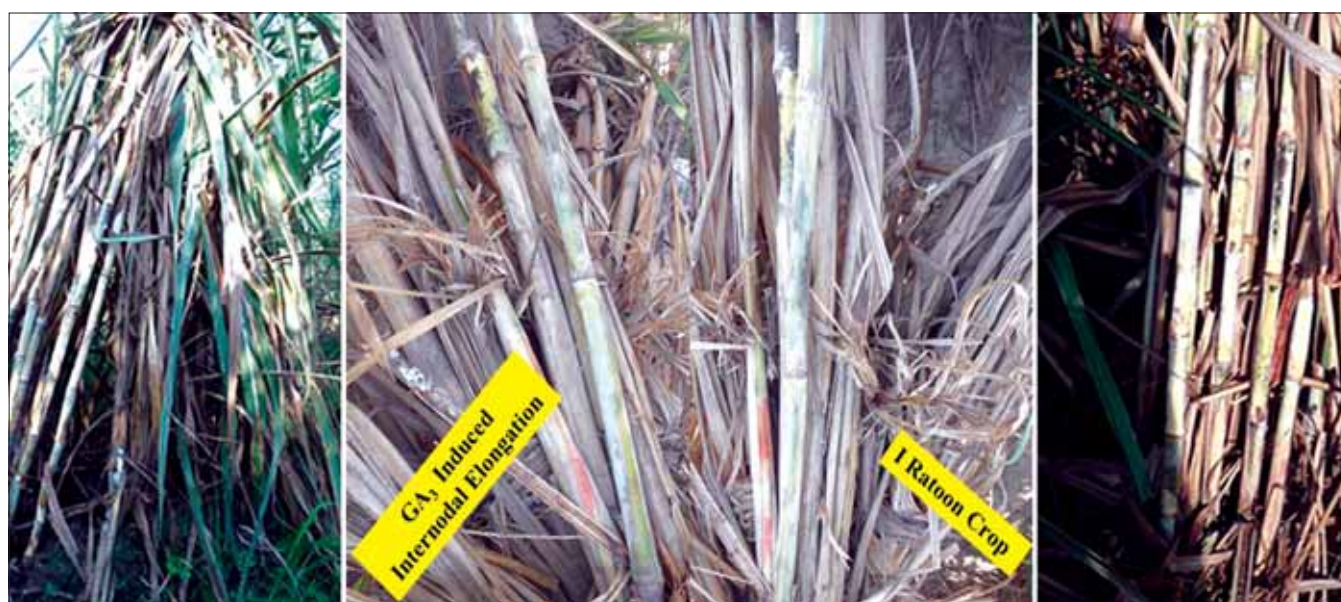


Fig 8. Number of millable canes in a clump and effect of *Pusa compost inoculant* and PGR application on internodal length



Fig 9. Effect of *Pusa compost inoculant* and PGR application on millable canes at harvest stage

of trash and use of plant growth regulators boosted the ratoon cane yield by 57.4% by improving the physico-chemical properties of the soil (organic carbon by 38%, available nitrogen by 20%, and available phosphorus by 26.5% and potash by 44.5%) and increasing tiller numbers, stalk elongation rates and number of millable canes (NMC, Fig. 9).

SUMMARY

Ratooning practice saves cost on preparatory tillage and planting material and benefits from the residual manure and moisture. However, yields are generally found to be lower than plant crop in the successive years under normal conditions. Usage of trash generated from the plant crop of sugarcane reduced soil compaction and

improved the availability of nutrients and moisture. Application of PGRs at various growth stages further mitigates the adverse effects of tiller mortality and poor assimilate accumulation and partitioning towards stalk. *In situ* decomposition of sugarcane trash (dispersed @ 12 tonne ha⁻¹) generated from the plant crop with Pusa compost inoculant (@ 300 g t⁻¹ of trash) and foliar applications of *Ethrel* and GA₃ at 60, 90, 120 and 150 days after planting increases tiller numbers during grand growth stage, reduces tiller mortality, increases NMC and ratoon crop yield by about 16.9 tonne ha⁻¹.

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