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Improved sugarcane productivity with tillage and trash management practices in semi arid tropical agro ecosystem in India

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ABSTRACT

Sugarcane productivity at the farm level has been stagnant in India, at around 54–72 t ha^{-1}. One of the main reasons for this low productivity is the yield gap between ratoon and plant cane yield. To improve the ratoon yield and bridge the yield gap, a field experiment was conducted for two seasons with different tillage systems and trash management practices. The treatments in main plots were T1—tillage by tractor drawn off barring (TT), T2—conventional tillage by the bullock drawn country plough (CT) and T3—no tillage (NT) along with seven types of trash management practices (viz., mulching, shredding combined with micro organisms etc.) as sub plots. The results revealed that Tillage by Tractor drawn off barring, (TT) combined with adoption of trash shredding + composted pressmud + wonder life (S4) treatment significantly improved the germination percentage, tiller number, number of millable canes and ultimately the ratoon cane yield in both the seasons. Similarly, soil physical parameters such as bulk density, mean weight diameter, water stable aggregates, soil moisture content were also significantly influenced by the above treatment when compared to control. Besides, root weight of cane, quality parameters of cane juice, soil available N and P, organic carbon, microbial biomass carbon and arbuscular mycorrhizal fungi (AMF) population also were significantly improved by the adoption of tillage and trash management practices. The results suggest that the tillage with adoption of trash management practices assisted in improving the profitability by way of higher sugarcane ratoon productivity and also in sustaining the soil fertility.

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1. Introduction

Sugarcane (*Saccharum officinarum*) is an important crop globally for not only sugar production, but also increasingly as a bio energy crop due to its phenomenal dry matter production capacity. Productivity at the farm level has been stagnant over the last two decades, at around 54–72 t ha^{-1} (SBI, 2015). One of the reasons attributed for this condition is the low productivity in ratoon with the value of 48–60 t ha^{-1} as compared with plant cane yield of 78–90 t ha^{-1} (personal communication from SBI). Ratooning is a practice of raising a sugarcane crop from the preceding plant crop stubble re growth without fresh planting of setts, and is an integral part of sugarcane cultivation practiced in most of the sugarcane growing countries of the world. Sugarcane ratooning saves the cost of seedbed preparation, seed material and planting operations thereby reducing 25–30% cost of sugarcane cultivation. Ratoon crop helps in extending the crushing period of sugar mills as they mature earlier than the plant crop and normally give better quality. However, most often ratoon crop yields are lower than the plant crop. Lin et al. (2013) stated that the productivity of the ratoon sugarcane was 33% less than the plant sugarcane due to increased mortality of stalks, reduction in soil nutrition status and abundance of pests and diseases in the soil. The major cause of low ratoon productivity in Pettavaithlalai sugarcane command[1] area is lack of plant population in ratoons (Surendran et al., 2007).

Even though the sugar factories and farmers insist on basal cutting of plant cane, the harvesting labourers usually leave a portion of stem cane varieties which inhibit the sprouting of stubble buds. Unsprouted stubble causes gaps in subsequent

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[1] Command area: government has demarcated cane growing area boundary for each factory. It implies that the factory has to take the sugarcane from the farmers only in the demarcated area.

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sugarcane ratoon crop resulting in lower initial plant stand and poor crop yield. With these kinds of low yields coupled with high input costs, lack of labour availability, water scarcity, pest and diseases, the sugarcane farmers are indeed in a desperate condition and hence needs to be addressed. Several agro techniques viz., stubble shaving, off barring, trash mulching (Yadav et al., 2009), intercropping, ratoon gap filling, earthing up, micro nutrient application and fertilizers have been suggested to improve cane yield (Verma and Yadav, 1988) in ratoon and to reduce the yield gap of ratoon. Among the practices, stubble shaving and off barring (basal cut of stubbles and removal of decayed roots, with tillage) provides proper soil cover to stubble and which enhances sprouting with vigorous tillers. The loose soil mass may create favourable rhizospheric environment for emergence of vigorous sprouts, thereby enhances rhizospheric biological activity, promoting new roots and ultimately helps in maintaining the plant population and yield.

Another important reason for low productivity is decline in soil fertility. The soil fertility has declined in many sugarcane growing areas due to improper and distorted fertilizer schedules adopted over years under intensive cultivation of the crop. On an average, sugarcane crop yielding 100 t ha^{-1} would remove 200–250 kg of N, 120–150 kg of P and 175–225 kg of K from soil. The command area[1] of Pettavaithalai (our study area) is deficit in N, medium in P and deficit in other micronutrients (Surendran et al., 2007). Soil organic matter (SOM) plays an important role in maintaining the productivity of tropical soils because it provides energy and substrates, and promotes the biological diversity that helps to maintain soil quality and ecosystem functionality (Wendling et al., 2010). Once soil is continuously cultivated for agricultural production, especially in the tropics and the semi-arid regions, SOM is rapidly decomposed due to modifications in soil physical properties such as aeration, soil temperature and water content (Ashagrie et al., 2007) and productivity of soil decline due to decrease in organic matter content and soil pH. This can affect many soil functions that are either directly or indirectly related to SOM, due to its capacity to retain water and nutrients. Although the breakdown rate of SOM can be faster in the tropics, regular inputs of organic amendments can promote a build-up of SOM (Follett, 2001). Regular additions of organic manures is considered to be an effective way to achieve soil organic carbon (SOC) sequestration and supplying micronutrients to crops in comparison with the use of chemical fertilizers alone (Lal, 2008; Jayakumar et al., 2014, 2015).

Regular addition of locally available organic resources like crop residues, green manures, green leaf manures, cover crops, vermicomposting and tank silt improve soil organic matter in agroecosystems (Surendran and Murugappan 2007a, 2007b, 2010; Marimuthu et al., 2013). A sugarcane crop yielding 100 t ha^{-1} produces 8–10 t of material in the form of trash alone. Plant growth and productivity is heavily influenced by the interactions between plant–roots and the surrounding soil, including the microbial populations within the soil. The indigenous rhizospheric microbial population of agricultural soils is greatly influenced by agricultural practices (e.g. soil cultivation, season, stubble retention, burning etc.), crop plant species, cultivar and genotype, as well as soil type (Reeve et al., 2010). Bioaugmentation, the addition of microbes to agricultural soils, thus becomes a valuable influence on soil microbial processes and addition of organic matter strongly influences these process (Lily and Mary, 2015). Studies have revealed that crop rotation breaks and organic amendments greatly influence the structure and microbial populations of the sugarcane rhizospheric soil (Pankhurst et al., 2005). Residue burning in fact increases the short-term availability of some nutrients (Ca and K) and reduces soil acidity, but leads to loss of other nutrients, organic matter and micro flora in top soil. Though farmers realize the importance of crop residue and its recycling, decomposition of these sugarcane trash is a problem either for direct addition as mulch or composting as manure. To overcome this, EID Research and Development team has introduced a trash shredder for *in situ* chopping or shredding of sugarcane crop residues. A field experiment was conducted for two seasons with different tillage systems and trash management practices. This aimed at determining the effects of different tillage practices and sugarcane trash application treatments on the growth and yield of sugarcane ratoon in semi arid region of India and their impact on the yield gap between plant and ratoon sugarcane crop.

2. Material and methods

2.1. Experimental site and soil characteristics

Field experiment was conducted in ratoon crops (R1 and R2) for two seasons at Research and Development farm of EID Parry located at Vishwanathapuram (10°53′57″N, 78°29′35″E) of Pettavaithalai, in Tamil Nadu, India. The study area is located in the western agro-climatic zone of Tamil Nadu in the southern part of India. The climate of the experimental site is semi-arid, subtropical with hot dry summers and cold winters. The annual rainfall received during the experimental season is 648 mm and nearly 80% of the rainfall is received from northeast monsoons during October to December. Initial soil samples were collected from the experimental plots and the samples were analysed for its physico-chemical properties using standard analytical procedures as mentioned in Table 1. The experimental area consists of red sandy loam with 62% sand, 20% silt, and 18% clay and belongs to Irugur Soil series with USDA taxonomical class of Kaolinite; Isomegathermic deep; Typic Ustorthents (Surendran et al., 2007).

2.2. Field experiment

The planting of sugarcane variety Co 86-032 was taken up in July (2007) in special season planting (June–October which predominantly occupies 63% of the total command area as per

Table 1
Soil analytical methods.

Soil parameter	Method	Reference	Plot values
Texture (sand, silt, clay)	Hydrometer	Day (1965)	Sandy loam
Soil pH	1:2.5 soil water		7.7
Organic carbon	Wet digestion	Walkley and Black (1934)	0.71%
Hydrolysable N	Alkaline permanganate	Subbiah and Agija (1956)	242.0 kg ha^{-1}
Olsen-P	Olsen method	Olsen et al.(1954)	16.5 kg ha^{-1}
Exchangeable K	Ammonium acetate extractable K	Stanford and English (1949)	490 kg ha^{-1}
Calcium	Ammonium acetate	Schwartzenbach et al., (1946)	475.4 mg kg^{-1}
Magnesium	-Do-	-Do-	134.5 mg kg^{-1}

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