

Original Research Article

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Effect of Consortium of Endophytic Nitrogen Fixing Bacteria on Nutrient Uptake and Soil Nitrogen Balance Study of Seasonal (SURU) Sugarcane under Drip Irrigation

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ABSTRACT

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The present investigation entitled “Effect of consortium of endophytic nitrogen fixing bacteria on yield and quality of seasonal (Suru) sugarcane (*Saccharum officinarum*) under drip irrigation” was carried out at AICRP on Water Management, M.P.K.V., Rahuri during 2014-15. The experiment was laid out in Randomized Block Design with six treatments and four replications. There were four levels of nitrogen (100%, 50%, 25% and 0%) with P₂O₅, K₂O, PSB, FYM and foliar application of consortium of endophytic nitrogen fixing bacteria with and without combination and set treatment of *Acetobacter diazotrophicus*. The results of the experiment conducted revealed that the higher total nutrient uptake for N, P and K (243.91, 60.20 and 205.47 kg ha⁻¹, respectively) was recorded in the treatment 25% N + Consortium of Endophytic Bacteria foliar spray. Soil nitrogen balance study revealed that there was a negative balance of nitrogen in all the treatments except RDF 100% N which has positive balance.

Introduction

Sugarcane (*Saccharum* spp. hybrid) is a tall, perennial grass (family Poaceae, subfamily Panicoide), and is cultivated in tropical and warm-temperate regions between 35°N and 35°S and from sea level to altitudes of 1,000 m in a wide variety of soil types (Reis *et al.*, 2007). Most of the commercial sugarcane varieties are hybrids with *Saccharum officinarum*. The optimal temperature for sugarcane cultivation is between 20 and 35°C and the minimum rainfall requirement is 1,200mm per year (Ando. 2010). The stalks (stems) of sugarcane are harvested at 9 to 18

months after planting the mother stem cutting (setts). Once planted, sugarcane can be harvested several times, because new stalks, called ratoons, repeatedly grow from the stubble. For many years, sugarcane has been used for sugar and an alcoholic drink production. It grows up to 2-6 m in height. In 2011, world production of sugarcane was 1,794 million tons (FAO STAT, 2011) which is much higher than other major crops such as maize (883 million tons), paddy rice (723 million tons), wheat (704 million tons) and potatoes (374 million tons). Sugarcane production is highest in Brazil (734 million tons), followed by India (342 million tons),

and China (115 million tons). Sugarcane was cropped over an area of 25 million hectares all over the world; the average yield was 70.5 tons per hectare. It has occupied 40.75 lakh ha. area in India, while 7.36 lakh ha. in Maharashtra state. Sugarcane being a long duration crop produces huge amount of biomass, and requires large quantity of water (1100-2200 mm) and is mostly grown as an irrigated crop using surface irrigation. The drip irrigation adoption in sugarcane increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation. However, if not installed properly, it may result in wastage of water, time, money and yield. Nitrogen is essential and primary nutrient, required by all crops in large amount. However, nitrogenous fertilizers added in soil get leached out or washed out. It not only causes economic loss but also leads to soil pollution, water pollution and environmental pollution. It causes harm to soil health as well as human health. The use of biofertilizers to some extent are useful and ecofriendly option to overcome these problems. Endophytic nitrogen fixing bacteria are associative type nitrogen fixers. They fix nitrogen by staying in tissues. Mostly they are present in sugar containing plants. Biological nitrogen fixation is the potential biological process that maintains the soil nitrogen status under normal conditions. In recent years nitrogen fixation by *G.diazotrophicus* in sugar rich crops has been well established. Biological nitrogen fixation effectively supplemented the need of nitrogen and minimizes the cost of production by reducing doses of nitrogenous fertilizers. Endophytic nitrogen fixation concept has been recently gaining momentum. Cultivation in the tropical regions entails least input package of practices and soils are generally low in the nutrient status (Dakora and Phillips, 2002) thus biologically fixed nitrogen can

supplement the nitrogen requirement of the crops. Major studies of endophytic diazotrophs are focused on sugarcane and kallar grass (Dobbelaeve *et al.*, 2003) thus identification of diazotrophs from other economically important plants is of considerable value for sustainable agriculture. It has been suggested to be an endophytic contributor of nitrogen to sugar rich crops, as it fixes nitrogen in culture medium under acidity levels, sugar concentration and micro aerobic conditions that resemble those inside the plants and it fixes or accumulates nitrogen to sugar rich plants between 10 to 180 kg per hectare per season.

Materials and Methods

The investigation was carried out at AICRP on Water Management, M.P.K.V., Rahuri during 2014-15. Soil was medium black it belongs to Inceptisols. The climate of this area is semi-arid. The seedling material of sugarcane Co.M-0265 (Phule - 0265) was procured from Chief Scientist, AICRP on Water Management, Department of Agronomy, M.P.K.V., Rahuri. The experiment was laid out in RBD design with four replications and six treatments including one control and one recommended dose of fertilizers. Basal dose of nitrogen, phosphorus, and potassium i.e. recommended dose (250:115:115 kg of N, P₂O₅ and K₂O ha⁻¹) along with organic manures i.e. full dose of FYM, *Acetobacter diazotrophicus* and PSB as per the different treatment details per plot and replication wise were given before transplanting of seedlings. Remaining doses of fertilizers were applied at 6-8, 12-14, 18-20 weeks after transplanting i.e. top dressing. Consortium of Endophytic Bacteria foliar spray were taken at 60 days after transplanting for treatments 4 and 5 in all the four replications. Two hand weedings were carried out to keep plots free from weeds. Irrigation schedule for drip at alternate day as per 100% ETc was fixed.

Details of treatments

T₁ - Absolute control (No fertilizers),

T₂ - RDF (100% N, P₂O₅ and K₂O)

T₃ - 50% N + *Acetobacter diazotrophicus* @ 10 kg.ha⁻¹ (set treatment)

T₄ - 25% N + Consortium of Endophytic Bacteria @ 3 L ha⁻¹ (500L water ha⁻¹) [foliar spray at 60 DAT]

T₅ - 0% N + Consortium of Endophytic Bacteria @ 3 L ha⁻¹ (500 L ha⁻¹) [foliar spray at 60 DAT]

T₆ - 0% N + without Consortium of Endophytic Bacteria.

NOTE: - 75% P₂O₅, 100% K₂O, 20 t.ha⁻¹ FYM, 1.25 kg.ha⁻¹,

PSB common to all treatments except T₁.

The Consortia of Endophytic Nitrogen fixing bacteria was applied as foliar application @ 3 lit ha⁻¹. (500 lit water) at 60 days after transplanting.

The following endophytic bacteria are the components of consortia:

Acetobacter
Agrobacterium
Burkholderia
Azospirillum
Herbaspirillum
Azoarcus

Nutrient uptake (leaf and cane)

The cane and fourth leaf samples were collected at harvest and were dried in the oven at 60°C till constant weight is achieved. The samples were ground to fine powder with the

help of whilly mill and then were further digested in Kjeldahl digestion unit (48 tubes set) at required temperature as suggested by (Parkinson and Allen 1975). Then acid extract was used for determining the concentration of N, P, K by using standard methods of analysis

The data was analyzed statistically by using randomized block design as per procedure described by (Panse and Sukhatme 1985).

Results and Discussion

Nutrient uptake

The data on the total nutrient uptake of seasonal sugarcane are presented in Table 01.

The treatment T₄ - 25% N + consortium of endophytic bacteria foliar spray recorded the highest uptake of nutrients by cane for N, P and K (236.03, 58.46 and 198.70 kg ha⁻¹, respectively).

The lowest uptake of N, P and K (112.49, 29.98, and 79.22 kg ha⁻¹, respectively) was recorded in the treatment T₁ (absolute control).

The treatment T₂ – RDF recorded the highest (8.12 kg ha⁻¹) uptake of nitrogen by sugarcane top which was at par with T₄ (7.88 kg ha⁻¹) and the highest uptake of phosphorus and potassium (1.90 and 7.45 kg ha⁻¹, respectively) by top was recorded in treatment T₅ - 0% N + consortium of endophytic bacteria foliar spray. The lowest uptake of N, P and K (5.54, 1.36, and 3.76 kg ha⁻¹, respectively) was recorded in the treatment T₁ (absolute control).

The total uptake of N, P and K was highest (243.91, 60.20 and 205.47 kg ha⁻¹, respectively) in the treatment T₄ - 25% N + consortium of endophytic bacteria foliar spray, and the lowest (118.02, 31.34 and 82.99 kg ha⁻¹, respectively) was recorded in the treatment T₁ (absolute control).

Table.1 Effect of consortium of endophytic nitrogen fixing bacteria on nutrient uptake by seasonal sugarcane at harvest

Treatments	Cane (kg ha ⁻¹)			Top (kg ha ⁻¹)			Total nutrient uptake (kg ha ⁻¹)		
	N	P	K	N	P	K	N	P	K
T ₁ Absolute control	112.49	29.98	79.22	5.54	1.36	3.76	118.02	31.34	82.99
T ₂ RDF (100% N,P ₂ O ₅ ,K ₂ O)	211.63	53.78	168.32	8.12	1.71	7.13	219.75	55.49	175.45
T ₃ 50% N + <i>Acetobacter diazotrophicus</i>	203.30	53.05	169.96	6.76	1.68	6.67	210.06	54.73	176.64
T ₄ 25% N + consortium of endophytic bacteria foliar spray	236.03	58.46	198.70	7.88	1.73	6.77	243.91	60.20	205.47
T ₅ 0% N + consortium of endophytic bacteria Foliar spray	178.11	48.08	169.10	7.30	1.90	7.45	185.40	49.98	176.55
T ₆ 0% N + without consortium of endophytic bacteria foliar spray	134.67	41.35	113.21	6.13	1.58	5.97	140.81	42.93	119.18
Mean	179.37	47.45	149.75	6.95	1.66	6.29	186.33	49.11	156.05
S.Em. ±	8.45	2.33	14.04	0.22	0.06	0.59	8.46	2.34	14.05
CD at 5 %	25.47	7.01	42.33	0.68	0.18	1.77	25.51	7.04	42.36

Table.2 Soil Nitrogen balance study under effect of consortium of endophytic nitrogen fixing bacteria on seasonal sugarcane

Sr. No.	Treatments	Initial nitrogen	Nitrogen added	Nitrogen uptake	Available Nitrogen at harvest	Net gain /loss of soil nitrogen	Nitrogen use efficiency kg kg ⁻¹
T ₁	Absolute control	134.8	0	118.02	119.17	-102.39	-
T ₂	RDF (100% N,P ₂ O ₅ ,K ₂ O)	134.8	250	219.75	153.66	11.39	288.76
T ₃	50% N + <i>Acetobacter diazotrophicus</i>	134.8	125	210.06	125.44	-75.70	697.20
T ₄	25% N + consortium of endophytic bacteria foliar spray	134.8	62.5	243.91	169.34	-215.95	1625.68
T ₅	0% N + consortium of endophytic bacteria foliar spray	134.8	0	185.40	137.98	-188.58	-
T ₆	0% N + without consortium of endophytic bacteria foliar spray	134.8	0	140.81	116.03	-122.03	-

The increase in nutrient uptake with soil application of fertilizers and consortia foliar spray was due to increased availability of nutrients to plants. Drip irrigation improved the soil environment, which encouraged proliferous root system resulting in better absorption of moisture and nutrients. The results confirm the findings of Bhalerao *et al.*, (2005), Muthukumarasamy *et al.*, (2006), Saini *et al.*, (2006) and Kumar (2012).

Soil nitrogen balance study

The data presented in Table 02 representing the Soil nitrogen balance study under effect of consortium of endophytic nitrogen fixing bacteria of seasonal sugarcane revealed that there was a negative balance of nitrogen due to application of 0% N (T₁), 50% N + *Acetobacter diazotrophicus* (T₃), 25% N + consortium spray (T₄), 0% N + consortium spray (T₅) and 0% N without consortium spray (T₆).

The balance of N in 100% RDF treatment may be due to addition of organic manures and 100 % inorganic nitrogen fertilizers which helped the plants for luxurious uptake as well as positive nitrogen balance in the soil. The nitrogen use efficiency of different treatments in split doses of nitrogen applied was T₂-RDF (288.76 kg kg⁻¹), T₃ of 50% N + *Acetobacter diazotrophicus* (697.20 kg kg⁻¹) and T₄ - 25% N + consortium of endophytic bacteria foliar spray (1625.68 kg kg⁻¹) respectively.

Similar results were also reported by Kumar (2012). The gain in availability of N might be due to application of recommended dose of fertilizers, addition of N through FYM and native N in soil.

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