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Influence of consortium of endophytic nitrogen fixing bacteria with levels of nitrogen on yield attributing characters of Pre-Seasonal sugarcane (Second Ratoon)

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Abstract
A field experiment was conducted during the year 2015-16 at the Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, and Rahuri, to study the "Effect of consortium of endophytic nitrogen fixing bacteria on yield, quality and nutrient uptake of pre-seasonal sugarcane (second ratoon). The experiment was laid out in randomised block design with four replications and six treatments. There were four levels of nitrogen 0, 25, 50 and 100% and 100% P_2O_5, 100% K_2O along with and without foliar spray of consortium of endophytic nitrogen fixing bacteria. The result of the experiment revealed that Total cane height, Millable cane height, Girth of internodes, Length of internodes and No. of millable canes of pre-seasonal sugarcane (second ratoon) were increased with foliar spray of consortium of endophytic bacteria along with 25% N of RDF. Among all the treatments, 100% N (RDF) recorded significantly highest yield attributing characters.

Keywords: sugarcane, second ratoon, consortium, endophytes

Introduction

Sugarcane (*Saccharum officinarum* L.) is a member of the Andropogoneae tribe of the Poaceae (grass) family. It is currently a crop of growing economic importance, considered one of the main agricultural commodities in terms of productivity (Devos, 2010) [2], grown in tropical or subtropical regions, mainly used for sugar and biofuel production (Kajihara, 2012) [6]. Sugarcane is economically more beneficial for farmers because four ratoons can be taken in sugarcane so can save expenditure of ploughing, harrowing, planting, *etc.* as well as nutrient residual effect can be beneficial for next ratoon crop.

Inoculation experiments involving micropropagated sugarcane, the positive colonization and its contribution to plant growth and development in terms of improved plant height, nitrogenase activity, leaf nitrogen, biomass and yield. The field trials conducted in sugarcane have shown that inoculation by *Gluconacetobacter diazotrophicus* with other diazotrophs or AM can match yield level equal to 275 kg N ha^{-1} application (Sevilla *et al*., 2001 and Boddey *et al*., 2003) [12, 1]. An increase in biomass production and leaf N-content of both micropropagated and sugarcane developed from buds when endophytic diazotrophic bacteria was inoculated together with arbuscular mycorrhizal fungi (Muthukumarasamy *et al*., 1999) [8]. In a study *Acetobacter, Azospirillum, Azotobacter, Bacillus, Burkholderia, Herbaspirillum,* and *Pseudomonas* species have been observed to improve plant growth through stimulation of root development (Dobbelaere and Okon, 2007) [4]. The application of RDF significantly increased cane and commercial cane sugar yield of pre-seasonal sugarcane and it was on par with 25% N with foliar application of consortium of endophytic bacteria at 3 L ha^{-1} at 60 days after planting. It could be concluded that 25% N + foliar application of consortium of endophytic bacteria was found beneficial for nutrient uptake of pre-seasonal sugarcane of cultivar Phule-265 (Dhole, 2015 and Rajbinde, 2016) [3, 11].

Material and Methods

The present investigation was carried out during February 2016 to January 2017 (pre-seasonal) to study the effects of application of consortium of endophytic nitrogen fixing bacterial culture on microbial population *(Gluconacetobacter diazotrophicus)* in sugarcane second ratoon grown on Inceptisol (Vertic Haplustept).

The site for the experiment was at Post Graduate Institute Research Farm of Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India). First pre-seasonal ratoon sugarcane was harvested in the month of February 2016 and second ratoon crop was continued. No new seedling setts for gap filling were used. It was laid out in randomized block design with four replications and six treatments.

The nitrogen, phosphorus and potassium were applied to crop through urea (46% N), single superphosphate (16% P_2O_5) and muriate of potash (60% K_2O) as per RDF for pre-seasonal sugarcane. There were different levels of nitrogen 0, 25, 50 and 100% of recommended dose of fertilizer with 100% P_2O_5 and 100% K_2O along with and without foliar sprays of consortium of endophytic nitrogen fixing bacteria at 60 days after ratooning.

An *Acetobacter diazotrophicus* culture and consortium of endophytic nitrogen fixing bacteria (consortium includes *Acetobacter spp., Azospirillum spp., Azoarcus spp., Agrobacterium spp., Burkholderia spp., Herbaspirillum spp.)* for the fixation of nitrogen in plant biologically was obtained from Department of Microbiology, Vasantdada Sugar Institute, Manjari, Pune (M.S.). *Acetobacter diazotrophicus* culture foliar application was given @ 2.5 $kg.ha^{-1}$ at 60 DAHR and liquid consortium of endophytic bacteria was applied as foliar application @ 3 L.ha-1 according to treatments at 60 DAHR.

The different levels of nitrogen, *Acetobacter diazotrophicus* culture and consortium of endophytic nitrogen fixing bacteria were applied in combination as per following treatment through soil and foliar sprays.

T1	-	Absolute control
T2	-	RDF +100% N (250 kg N ha^{-1})
T3	-	50% N + *Acetobacter diazotrophicus*@ 2.5 $kg.ha^{-1}$ (foliar spray at 60 DAHR)
T4	-	25% N + Consortium of endophytic bacteria @ 3 $L.ha^{-1}$ (foliar spray at 60 DAHR)
T5	-	Consortium of endophytic bacteria @ 3 $L.ha^{-1}$ (foliar spray at 60 DAHR)
T6	-	Without consortium of endophytic bacteria

Note

1. 100% P_2O_5 and 100% K_2O common to all treatments except T_1.
2. RDF of pre-seasonal sugarcane (ratoon) (250:115:115 N, P_2O_5, K_2O ha^{-1}) is applied for pre-seasonal sugarcane (second ratoon).
3. DAHR-days after harvesting of ratoon.

Intercultural operations like weeding, spraying of insecticide, fertilizer application and schedule of irrigation for ratoon sugarcane crop was carefully followed. The cop variety used was Co- 265. The data obtained was carefully analyzed and appropriately interpreted as per the methods described in "Statical Methods for Agricultural Workers" by Panse and Sukhatme, (1985) [9].

Results and Discussions

The data on total cane height, millable cane height and no. of millable canes are depicted in Table 1, Fig 1 and Fig 2.

Total cane height was significantly higher (395 cm) in RDF treatment (T_2) over rest of the treatment except T_4 (391 cm). The improvement in plant height might be due to attributed to the higher nitrogen uptake as compared to other treatments; similar results were also reported by Hunsigi *et al.* (2001) [5] for sugarcane by using endophytic bacteria. The improvement in plant height with different treatments (*Acetobacter*, *Azotobacter* and *Azospirillum*) was also reported by Paula *et al*. (1991) [10] for sugarcane and sorghum.

Millable cane height of second ratoon sugarcane was recorded at harvest are presented in Table 1, Fig 1 and 2. Millable cane height significantly higher (259 cm) in RDF treatment (T_2) over rest of treatment except 25% N with foliar application of endophytic N fixing bacteria (T_4) (254 cm). Although nitrogen level was low in T_4 *i.e.* 25% N with foliar application of endophytic N fixing bacteria and T_5 *i.e.* foliar application of endophytic N fixing bacteria. The higher plant height and millable cane height was might be due to production of growth substances and enhanced nutrient uptake by use of endophytic bacteria.

The number of millable cane ranged from 104 000' ha^{-1} (T_1) to 113 000' ha^{-1} (T_2). The effect of RDF on number of millable canes were nearly similar in T_4 *i.e.* 25% N and with foliar application of consortium of endophytic bacteria. The effect of T_3 *i.e.* 50% N + *Acetobacter diazotrophicus* (foliar application) on number of millable canes were nearly similar for T_5 *i.e.* with foliar application of consortium of endophytic bacteria.

The tillers which are formed upto 120 days are converted into millable cane. The similar results were also obtained by Muthukumarswamy (1995) [7].

Table 1: Total cane height, millable cane height and no. of millable canes of pre-seasonal sugarcane (second ratoon) as influenced by levels of nitrogen with consortium of endophytic bacteria.

S. No	Tr. No.	Treatment	Total cane height (cm)	Millable cane height (cm)	No. of millable canes ('000 ha^{-1})
1	T_1	Absolute control	327	220	104
2	T_2	RDF (100% N)	395	259	113
3	T_3	50% N + *Acetobacter diazotrophicus* (foliar application)	376	236	109
4	T_4	25% N + foliar application of consortium of endophytic bacteria	391	254	112
5	T_5	Foliar application of consortium of endophytic bacteria	340	242	107
6	T_6	Without consortium of endophytic bacteria	336	232	105
S.E. ±			5.78	5.19	0.48
C.D. at 5%			17.42	15.64	1.45

The data on length of internodes and girth of internode are depicted in Table 2 and Fig 1.

Girth of sugarcane internode was higher in T_2 *i.e.* RDF 100% N and T_4 *i.e.* 25% N + foliar application of consortium of endophytic bacteria treatment. T_3 and T_5 treatment showed same girth of internode. Treatment T_6 *i.e.* without consortium of endophytic bacteria and T_1 *i.e.* absolute control (10 cm) also observed same girth of internode.

Length of sugarcane internode was higher in T_2 *i.e.* RDF 100% N (12 cm) over rest of the treatment except T_3 *i.e.* 50% N + *Acetobacter diazotrophicus* (foliar application) and T_4 *i.e.* 25% N + foliar application of consortium of endophytic bacteria treatment observed same length of internode (11 cm). T_6 *i.e.* without consortium of endophytic bacteria, T_5 *i.e.* foliar application of consortium of endophytic bacteria and T_1 *i.e.* absolute control (9 cm) observed same length of internode.

Table 2: Girth and length of internodes of pre-seasonal sugarcane (second ratoon) as influenced by levels of nitrogen with consortium of endophytic bacteria.

Sr. No.	Tr. No.	Treatment	Girth of internode (cm)	Length of Internode (cm)
1	T_1	Absolute control	10	9
2	T_2	RDF (100% N)	12	12
3	T_3	50% N + *Acetobacter diazotrophicus* (foliar application)	11	11
4	T_4	25% N + foliar application of consortium of endophytic bacteria	12	11
5	T_5	Foliar application of consortium of endophytic bacteria	11	9
6	T_6	Without consortium of endophytic bacteria	10	9
S.E. ±			0.41	0.39
C.D. at 5%			1.24	1.17

Thus, results of yield attributing characters of sugarcane under T_2 (RDF) treatment as well as under lower levels of nitrogen (25% N) along with foliar application of consortium of endophytic bacteria did not differ although the results are significant in respect of yield attributing characters such as cane height, length and girth of internodes and no. of millable canes.

Conclusion

The recommended dose of fertilizer treatment (250 kg N, 115 kg P_2O_5 and 115 kg K_2O ha^{-1}) gave significantly highest yield contributing characters (total cane height, millable cane height and no. of millable canes, girth and length of internodes). These results were at par with treatment 25% N with foliar application of consortium of endophytic bacteria (T_4). Application of 25% of recommended dose of N (62.50 kg N ha^{-1}) + 100% P_2O_5 (115 kg P_2O_5 ha^{-1}) + 100% K_2O (115 kg K_2O ha^{-1}) and foliar application of consortium of endophytic bacteria @ 3 $L.ha^{-1}$ in 500 L of water at 60 days after harvesting of pre-seasonal sugarcane (second ratoon) positively beneficial for microbes with ecofriendly use of nitrogenous fertilizer.

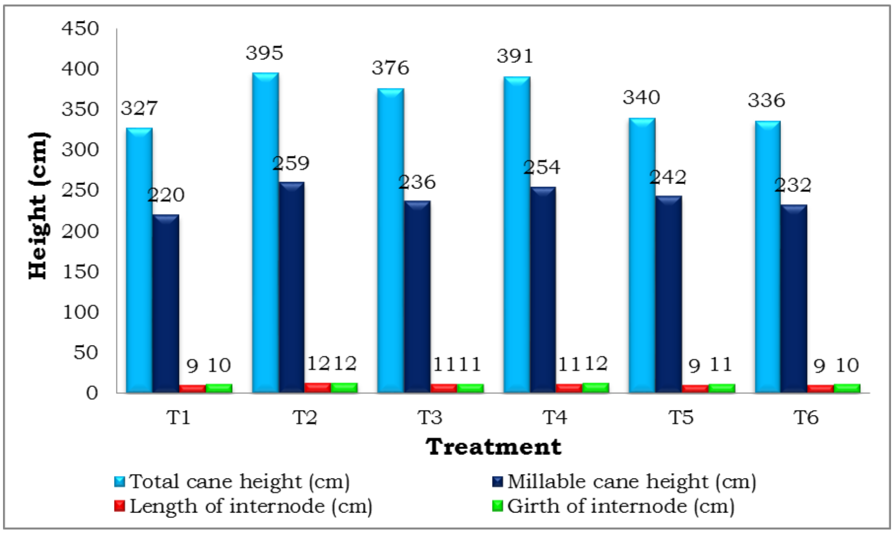

Fig 1: Total height, millable cane height, length and girth of internode of pre-seasonal sugarcane (second ratoon) as influenced by levels of consortium of endophytic nitrogen fixing bacteria.

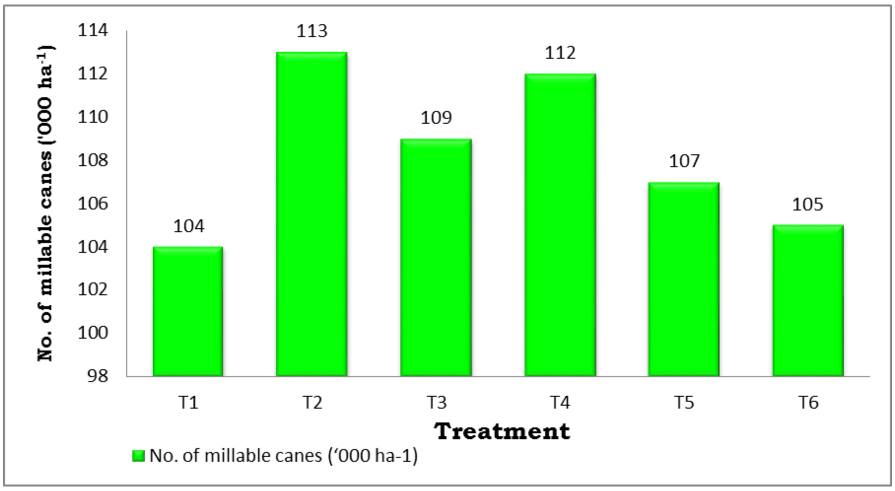

Fig 2: Number of millable canes of pre-seasonal sugarcane (second ratoon) by levels of consortium of endophytic nitrogen fixing bacteria.

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