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Impact of Microbial Inoculants and Fertilizers on Nutrient Uptake and Yield of Sugarcane Short Crop

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Perumallapalle, Tirupati, Acharya N. G. Ranga Agricultural University, Andhra Pradesh, India during 2021-22 to study the effect of microbial inoculants and fertilizers on nutrient uptake and yield of sugarcane short crop. The experiment was laid out in randomized block design with ten treatments and replicated thrice. The treatments consist of 75%, 100% and 125% RDF in combination of solid and liquid microbial inoculants (*Gluconacetobacter*, PSB and KSB). Data on N, P, K and S uptake by plant at different stages and yield were recorded. Results revealed that application of 100% RDF along with sett treatment with liquid *Gluconacetobacter* @ 1 lit ha^{-1}, PSB @ 1 lit ha^{-1} and KSB @ 1 lit ha^{-1} resulted significantly the highest N, P, K and S uptake by plant and seed cane yield followed by 100% RDF + sett treatment with solid *Gluconacetobacter* @ 10 kg ha^{-1}, PSB @ 1.25 kg ha^{-1} and KSB @ 1.25 kg ha^{-1}.

Key words: *Fertilizers, Microbial inoculants, Nutrient uptake sugarcane and yield.*

Introduction

Sugarcane is having a unique character among the commercial crops as several succeeding cane crops are raised from a single planting which is an integral component of the sugarcane production system. Sugarcane (*Saccharum officinarum*) is an nutrient exhaustive crop that can uptake great amount of soil nutrients for its biomass production. In addition to micronutrient exportation, about 65 kg N, 90 kg P_2O_5 and 170 kg K_2O are taken up for a target yield of 50 t ha^{-1} (Kathiresan, 2008). Continuous use of chemical fertilizers alone leads to deterioration of soil health and also causes ill effects on environment. The soil nitrogen reserve under this crop, however, increased by 50 % of the initial value which clearly indicated that the root-associated diazotrophs contribute significant quantity of nitrogen for sustaining the production of sugarcane (Suman, 2003). Inoculation of N-fixing microbes to sugarcane has increased the cane yield by 5–15 % and also improved the juice quality parameter, *viz.*, sucrose and purity (Hari 2005).

Gluconacetobacter diazotrophicus is a nitrogen-fixing bacterium highly specific to sugar rich crops. It can excrete about half of its fixed nitrogen in a form

(²Senior Scientist, ³Assistant Professor, ⁴Senior Scientist) that plants can use. It has also been reported that besides N fixation, all the strains of G. *diazotrophicus* produced indole acetic acid in a culture medium supplemented with tryptophan in the range of 0.14 to 2.42 l g ml^{-1} (Fuentez *et al*., 1993). Furthermore, it has been reported its ability to solubilize inorganic phosphates from the soil and make available P for the inoculated crops. Hence, *Gluconacetobacter* inoculation to sugarcane significantly increased the dry matter production and number of stalks, resulting in the more cane yield. PSB application which constitutes increased P solubilization by production of organic acids which solubilize the fixed form of phosphates into available form resulting in more available P in soil. KSB is more effective in releasing K from inorganic and insoluble pools of total soil K through solubilization. Sugarcane crop has shown good response to fertilizers and biofertilizers. Due to increasing the cost of fertilizers need to maintain soil health and for sustainable yields it is essential to address integrated use of chemical and biofertilizers. However the research on response of sugarcane short crop to chemical and biofertilizers (solid and liquid) is very scanty. With this view, a field experiment was conducted to study the effect of soil application and sett treatment of solid and liquid *G. diazotrophicus,* PSB and KSB along with fertilizers on nutrient uptake and yield of sugarcane short crop.

Materials and Methods

A field experiment was conducted during 2021-22 at Agricultural Research Station, Perumallapalle, Tirupati, Acharya N. G. Ranga Agricultural University, which geographically situated at 13° 36' 761'' N latitude and 79° 20' 704'' E longitude with an altitude of 182.9 m above the mean sea level, which falls under Southern Agro climatic Zone of Andhra Pradesh. The experiment soil was sandy loam in texture, neutral in reaction (7.36), normal in soluble salt concentration (0.232 dS m^{-1}), low in organic carbon (0.49 %), available nitrogen (212 kg ha^{-1}) and medium in available phosphorus (40.12 kg ha^{-1}) and high in available potassium (282 kg ha^{-1}). The experiment consist of ten treatments *viz*., T1: 100% RDF, T2 : 125% RDF, T3: 100% RDF+ soil application of solid *Gluconacetobacter* + PSB + KSB, T4 : 100% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB, T5 : 75% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB, T6 : 75% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB, T7 : 100% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB, T8 : 100% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB, T9 : 75% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB and T10: 75% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB and laid out in randomized block design with three replications. The crop was sown with a seed rate of 40,000 three budded setts ha^{-1}. The variety Swarnamukhi was planted. Recommended dose of inorganic fertilizers 224:112:112 kg N: P_2O_5: K_2O ha-1, respectively was applied as per the treatments. Solid *Gluconacetobacter*, PSB and KSB were applied @ 10 kg ha^{-1} each for soil application. The recommended dose of solid biofertilizers for sett treatment was 10 kg - 1.25 kg - 1.25 kg ha^{-1} of *Gluconacetobacter,* PSB and KSB, respectively. Recommended dose of liquid *Gluconacetobacter*, PSB and KSB for soil application was 1 lit, 1.25 lit and 1.25 lit ha^{-1}, respectively. Similar quantity of liquid *Gluconacetobacter*, PSB and KSB was used for sett treatment. All the other recommended practices were also adopted as per the crop requirement. Data on cane yield was recorded at harvest.

The whole plant samples were collected at tillering, grand growth and harvest stages. The plant samples were washed in sequence with tap water, 0.1 N HCl solution and distilled water and extra moisture was wiped out and dried in shade. Finally, the samples were dried in hot air oven at 70°C. The dried samples were powdered in willey mill and preserved in butter paper covers for chemical analysis. The dried plant samples were digested with diacid mixture. The digested samples were diluted with double distilled water and make up to 100 ml and filtered. The filtered solution was used for estimation of nutrient content. The nitrogen content in plant samples was determined by micro kjeldahl distillation method (AOAC, 1970). The phosphorus content in diacid extract was determined by Vanado molybdo phosphoric yellow colour method by using spectrophotometer (Systronics UV VIS Spectrophotometer 119) (Jackson, 1973). The content of potassium in diacid extract was determined by using flame photometer (Systronics flame photometer 128) method given by Jackson, 1967. Sulphur content in diacid extract was determined by turbidometric method using spectrophotometer (Systronics UV VIS Spectrophotometer 119) (Vogel, 1973). Nutrient uptake by plant was calculated by using the following formulae. All the canes in net plot of each treatment were harvested to ground level individually at the time of harvest and the cane weight was recorded in kg per net plot after detrashing and detopping just below the spindle and expressed in t ha^{-1}. The data was statistically analyzed by following the analysis of variance for randomized block design as outlined by Panse and Sukhatme (1985). Statistical significance was tested with 'F' test at 5 percent and 1 per cent level of probability. Further, multiple comparison tests have been done using Duncan's multiple range test (DMRT) to identify the homogenous groups of treatments using SPSS-20.

Results and Discussion

Nutrient Uptake by Sugarcane

Nitrogen Uptake

Nitrogen (N) uptake by sugarcane plant at tillering, grand growth and harvest was significantly effected by treatments. Significantly the highest N uptake by plant at tillering, grand growth stage and harvest (58.15, 160.0 and 381.5 kg ha^{-1}, respectively) was registered with 100% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB (T_8) followed by 100% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB (T_4) (54.94, 156.0 and 369.3 kg ha^{-1}, respectively) and 100% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB (T_7) (51.98, 153.0 and 362.6 kg ha^{-1}, respectively). Application of microbial inoculants along with RDF supplied more nitrogen through nitrogen fixation and accelerated the rate of nitrification which increased the nitrogen availability in soil. Higher availability of nutrients and their supply to the roots might have helped in nutrient absorption. The present findings are in agreement with Banarjee *et al.* (2018) who observed that nitrogen uptake was higher with combined application of organic manure, bio fertilizer and inorganic fertilizers. The progressive increase in nitrogen uptake from tillering stage to harvest also might be due to increased dry matter accumulation with the advancement in age of crop. The present results are in close conformity with the earlier findings of Bhalerao *et al*. (2006), Shankaraiah (2007), Tyagi *et al*.

Table 1. Nitrogen and phosphorus uptake by sugarcane short crop at different growth stages as influenced by application of microbial inoculants and fertilizers.

Treatments	N Uptake (kg ha^{-1})			P Uptake (kg ha^{-1})		
	Tillering stage	Grand growth stage	At harvest	Tillering stage	Grand growth stage	At harvest
T1 : 100% RDF	43.43i	136.3i	330.9h	15.42h	32.85g	68.08h
T2 : 125% RDF	48.43fg	146.0fg	346.1f	19.26e	39.98de	73.46fg
T3 : 100% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	51.04d	152.3c	358.4d	20.37d	42.19c	77.06c
T4 : 100% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	54.94b	156.0b	369.3b	22.34b	48.00b	81.09b
T5 : 75% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	47.15h	141.0h	340.1g	17.54g	35.85f	72.05g
T6 :75% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	48.92ef	148.1ef	351.3e	19.49e	39.05e	75.07de
T7 : 100% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	51.98c	153.0c	362.6c	21.28c	45.63c	78.05c
T8 : 100% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	58.15a	160.0a	381.5a	23.38a	53.23a	85.01a
T9 : 75% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	47.99gh	144.5g	347.8ef	18.46f	36.81f	74.08ef
T10 : 75% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	49.64de	149.4de	355.2d	19.80e	41.21d	75.46de
F-Value	198.57*	62.33**	148.5**	156.8**	92.82**	73.31**
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

**Significant at P = 0.01 level *Significant at P = 0.05 level

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT).

(2011) and Vajantha *et al*. (2017).

Phosphorus Uptake

Application of microbial inoculants and fertilizers exerted significant influence on phosphorus (P) uptake by sugarcane plant at tillering, grand growth and harvest. Significantly the highest P uptake (23.38, 53.23 and 85.01 kg ha^{-1}, respectively) by sugarcane short crop was recorded with 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB (T8) followed by 100% RDF + sett treatment with solid Gluconacetobacter + PSB + KSB (T4) (22.34, 48.00 and 81.09 kg ha^{-1} at tillering, grand growth stage and at harvest, respectively) and 100% RDF + soil application of liquid Gluconacetobacter + PSB + KSB (T7) (21.28, 45.63 and 78.05 kg ha^{-1}, respectively) at tillering, grand growth and harvest stages respectively. Higher P uptake with application of 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB might be due to application of P fertilizer along with PSB and Gluconacetobacter causes solubilization of insoluble inorganic phosphate compounds and chelation of complex intermediate organic molecules produced by microbial activity resulting more P available to the plants. Increased availability of phosphorus from native soil and dissolution of fixed phosphorus into soil available pool as facilitated by the applied microbial inoculants resulted more P content, dry matter production and better uptake of phosphorus by sugarcane. Similar findings are reported by Sundara *et al*. (2002) and Pyone *et al*. (2021).

Potassium Uptake

Potassium (K) uptake by sugarcane plant at tillering, grand growth and harvest was significantly affected by treatments. Significantly the highest K uptake (74.19, 196.8 and 395.3 kg ha^{-1}, respectively) by sugarcane short crop was observed with 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB (T8) followed by 100% RDF + sett treatment with solid Gluconacetobacter + PSB + KSB (T4) (70.46, 185.3 and 379.9 kg ha^{-1}, respectively) and 100% RDF + soil application of liquid Gluconacetobacter + PSB + KSB (T7) (66.99, 177.1 and 370.3 kg ha^{-1}, respectively) at tillering, grand

Table 2. Potassium and sulphur uptake by sugarcane short crop at different growth stages as influenced by application of microbial inoculants and fertilizers.

Treatments	K Uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Tillering stage	Grand growth stage	At harvest	Tillering stage	Grand growth stage	At harvest
T1 : 100% RDF	55.04^{h}	148.0^{h}	340.4^{g}	10.39^{h}	17.24^{f}	36.90^{ef}
T2 : 125% RDF	62.51^{f}	163.2^{f}	351.1^{f}	13.04^{f}	21.02^{e}	43.13^{ef}
T3 : 100% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	66.09^{c}	170.9^{d}	363.7^{d}	13.91^{d}	24.00^{c}	48.08^{c}
T4 : 100% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	70.46^{b}	185.3^{b}	379.9^{b}	15.47^{b}	26.11^{b}	54.18^{b}
T5 : 75% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	59.52^{g}	159.0^{g}	357.4^{e}	11.90^{g}	20.09^{e}	41.28^{f}
T6 :75% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	64.69^{e}	167.6^{e}	358.4^{e}	13.13^{ef}	22.46^{d}	45.18^{de}
T7 : 100% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	66.99^{c}	177.1^{c}	370.3^{c}	14.45^{c}	24.09^{e}	50.09^{c}
T8 : 100% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	74.19^{a}	196.8^{a}	395.3^{a}	17.86^{a}	29.14^{a}	59.29^{a}
T9 : 75% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	62.66^{f}	164.2^{f}	355.2^{ef}	12..38^{g}	21.99^{de}	44.21^{ef}
T10 : 75% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	65.43^{de}	169.2^{e}	360.6^{e}	13.63^{d}	23.04^{d}	45.20^{d}
F-Value	200.5**	155.22**	86.32**	141.5**	74.10**	39.6**
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

**Significant at P = 0.01 level

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT).

growth and harvest stages respectively. Higher K uptake with application of 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB might be due to application of K fertilizer along with KSB causes solubilization of potassium from K bearing minerals through organic acids released that could have increased potassium availability and absorption of potassium play an important role in activation of several enzymes which are involved in energy metabolism, starch synthesis, nitrate reduction and physiological processes leads to enhanced photosynthesis and vigorous growth, inturn more dry matter production causes more K uptake by plant. The present results are in agreement with the findings of Goswami and Maurya (2020).

Sulphur Uptake

Sulphur (S) uptake by sugarcane plant at tillering, grand growth and harvest was significantly affected by treatments. Significantly the highest S uptake (17.86, 29.14 and 59.29 kg ha^{-1}, respectively) by sugarcane short crop was observed with 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB (T8) followed by 100% RDF + sett treatment with solid Gluconacetobacter + PSB + KSB (T4) (15.47, 26.11 and 54.18 kg ha^{-1}, respectively) and 100% RDF + soil application of liquid Gluconacetobacter + PSB + KSB (T7) (14.45, 24.09 and 50.09 kg ha^{-1}, respectively) at tillering, grand growth and harvest stages respectively. Highest S uptake with 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB at every stage of crop growth might be due to increased supply of sulphur and also more dry matter production through combined application of microbial inoculants and fertilizers to the crop. Similar findings were reported by Banerjee *et al*. (2018).

Seed Cane Yield

Cane yield of sugarcane short crop was significantly differed with microbial inoculants and fertilizers application (Table 2). Significantly the highest seed cane yield (97 t ha^{-1}) was recorded with the application of 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB (T8) followed by 100% RDF + sett treatment with solid Gluconacetobacter + PSB + KSB (T4) (92 t ha^{-1}). The control (100% RDF) (T1) produced significantly the lowest cane yield (69 t ha^{-1}). The highest cane yield with 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB might be due to direct utilization of sugars present in setts by microbes as a food source which inturn leads to more microbial multiplication and leads to production of growth promoting substances. It helps in more growth with high photosynthesis and most of substrates move from source to sink i.e., cane leads to more cane yield. Sufficient quantity of nutrients supplied to plant through chemical fertilizers provides readily available nutrients and application of biofertilizers may hasten the constant nutrient supply by nitrogen fixation in the rhizosphere, solubilization of mineral nutrients, enhanced rooting and plant establishment, better uptake of low mobile ions such as P, improved nutrient cycling, improved plant tolerance to stress (biotic and abiotic) and ame-

Table 3. Seed cane yield of sugarcane short crop as influenced by application of microbial inoculants and fertilizers

Treatments	Seedcane yield (t ha^{-1})
T1 : 100% RDF	69h
T2 : 125% RDF	77f
T3 : 100% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	85d
T4 : 100% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	92b
T5 : 75% RDF + soil application of solid *Gluconacetobacter* + PSB + KSB	74g
T6 :75% RDF + sett treatment with solid *Gluconacetobacter* + PSB + KSB	82e
T7 : 100% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	88c
T8 : 100% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	97a
T9 : 75% RDF + soil application of liquid *Gluconacetobacter* + PSB + KSB	81e
T10 : 75% RDF + sett treatment with liquid *Gluconacetobacter* + PSB + KSB	84d
F-Value	80.08**
P-Value	<0.01

**Significant at P = 0.01 level
Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT).

lioration of physical and biological environment. (Surendran and Vani, 2013). Similar results were reported by Indi *et al.* (2014), Murumkar *et al*. (2017) and Vajantha *et al*. (2019).

Conclusion

Combined application of 100% RDF + sett treatment with liquid Gluconacetobacter + PSB + KSB is the most efficient nutrient management practice to obtain better growth, nutrient uptake and higher yields of sugarcane short crop. Hence, it is the best practice to sustain higher productivity and to achieve economic profitability in Southern Agroclimatic Zone of Andhra Pradesh.

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