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Enzyme Activity and Rhizosphere Microflora under Sugarcane Monocropping as Influenced by Integrated Nutrient Management

CH.S.RAMA LAKSHMI*, T.SREELATHA, A.SIREESHA, P.JAMUNA and M.BHARATHA LAKSHMI

Regional Agricultural Research Station, Anakapalle Visakhapatnam, Andhra Pradesh, India.

Abstract

Sugarcane is one of the lead crops in North Coastal Andhra Pradesh. Farmers in North Coastal Zone are opting for raising more number of ratoons owing to its substantially low cost of production. Ratoon crops however seldom receive proper care and inputs due to considered it as a bonus crop by majority of farmers. Field experiments were conducted consecutively for six years in the same field (2012-13 to 2018-19) at RARS, Anakapalle to study the monocropping effect on soil biology under the influence of different nutrient management practices. Irrespective of the year of ratooning, plots which received 50 % recommended dose of chemical fertilizers + 25 % nitrogen though vermicompost + 25 % nitrogen through green manure incorporation resulted in higher microbial population over chemical fertilizers alone. Activity of dehydrogenase and active carbon pool also showed similar trend in multi-ratooning system of sugarcane. Rhizosphere microbial population at different growth stages revealed that, azospirillum population was observed highest followed by azotobacter while lowest population counts of phosphorus solubilizing bacteria were observed. Highest population counts were recorded in INM plots and population was highest at formative later reduced to harvest. INM with 50 % RDFN + 50 % through organics (66.80 t ha^{-1}) recorded at par yields with 100 % RDF (67.28 t ha^{-1}).

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Introduction

Sugarcane (*Saccharum officinarum* L.) is one of the most important cash crops in India and plays pivotal role in both agricultural and industrial economy of our country. Sugarcane cultivation in India is characterized by raising of as many number

CONTACT Ch.S.Rama Lakshmi sitaramalakshmi20@yahoo.com Regional Agricultural Research Station, Anakapalle Visakhapatnam, Andhra Pradesh, India.

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of ratoons owing to its substantially low cost of production. Ratoon crops however, seldom receive proper care and inputs due to being considered a free crop by majority of farmers poor in resources. Such a approach for a long duration production system, often leads to significant deterioration in soil health (Singh *et al.,* 2007). Multiratooning of sugarcane is highly profitable to the farmers and sugar industry as it reduces the production cost by 30-40 %. But productivity of sugarcane under multiratooning is declined by 30-50 % every year due to alteration of soil physical, physicochemical and biological properties which leads to reduction in cane population per hectare. Sugarcane crop produces huge biomass and remove large quantity of plant nutrients from the soil. Indiscriminate use of mineral nutrients and continuous use of higher doses of chemical fertilizers on the other hand raises the cost of production so high that renders the system unprofitable.[7] Sugarcane crop produces a heavy tonnage and tends to remove substantial quantum of plant nutrients from the soil. A cane crop producing the cane yield of 100 t/ha removes about 208kg N, 53 kg of P, 280 kg K, 3.4 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from soil (Yaduvanshi and Yadav, 1990). For achieving the higher cane yield, most balanced use of fertilizer nutrients is the important management factor of cultivation. Use of inorganic fertilizer alone cannot maintain the soil fertility and use of organic manures is inevitable for sustained agricultural nutrients and counteract adverse effect of agro production. Slow release of nutrients from organics, could help a long duration sugarcane crop to take their complete benefit. Keeping in this view, present study on effect of different integrated nutrient management practices on soil biology under sugarcane multiratooning was undertaken up.

Materials and Methods

Experiment was conducted under red loamy soils of North Coastal Andhra Pradesh at RARS, Anakapalle, Andhra Pradesh consecutively for six years. The Experimental soils are neutral in reaction, non saline in conductivity, medium in per cent organic carbon (0.54 %), low in available nitrogen (254 kg ha^{-1}) and high status of available phosphorus and potassium. Subsequent ratoon crops received different treatments. The treatmental details for ratoon crops are as follows :

- T1:100 % Fertilizers on Recommended Dose–RDFNPK (224 : 100 : 120 kg NPK per ha),
- T2: 75 % RDFN + KNO_3 @ 1% foliar spray + cane trash in situ decomposition,
- T3: 50 % RDFN + 25 % N though trash compost + green manure incorporation,
- T4: 150 % RDFN,
- T5: 200 % RDFN, T6: Farmers practice (only N as initial dose (250 kg N as urea + 60 kg K as muriate of potash, no stubble shaving, no off bearing and no inter cultivation) and
- T7: 100 % RDFN + Hormonal spray i.e GA @ 50 ppm.

Common dose of 100 kg phosphotic fertilizers and 120 kg potassic fertilizers were applied in all the plots in the form of single super phosphate and muriate of potash except T6. Experiment was laid out in a randomized block design with 3 replications. Nitrogen fertilizers were applied at 0 and 45 days after ratooning and phosphorus and potassic fertilizers were applied at the time of stubble shaving. Soil samples collected from rhizosphere were collected and assayed for soil microbial population and dehydrogenase enzyme activity.[3] Soil samples were analyzed as per the standard procedures.[(5)] Cane yields were multiplied with % CCS and obtained sugar yields. Analysis of Variance (ANOVA) was performed by using standard procedures for split plot design.[4]

Results and Discussion

Soil Dehydrogenase Activity

Irrespective of the treatments dehydrogenase activity was gradually increased to formative phase from its initial and later decreased to grand growth phase and at harvest. Among different treatments highest dehydrogenase activity was recorded in treatments which received integrated nutrient sources over chemical fertilizers alone at all the crop growth stages. It might be due to availability of organic matter in these treatments through different organic manures.[5]

Rhizosphere Microbial Population

Data on nitrogen fixers revealed that, Azosprillium population was more than azatobacter population at different growth stages and it was observed that microbial population was gradually increased to formative and then decreased to grand growth in all the treatments. Microbial population also followed the same trend as dehydrogenase activity evidenced by more population counts. Phosphorus solubilizing bacteria was very low at all stages of the crop growth and it was slightly higher at formative stage than other stages and there is no particular trend among different treatments. Total bacterial and actinomycetes population also followed the same trend as like nitrogen fixers.[6]

Soil Organic Carbon

Irrespective of the year of ratooning, plots which received 50 % chemical fertilizers + 25 % nitrogen though vermicompost + 25 % nitrogen through green manure incorporation resulted in the higher OC, it was increased to 0.80 % from its initial value of 0.54 %. Lowest OC of 0.73 % was recorded in the farmers practice. Combined application of organic manures with inorganic fertilizers significantly increase the soil organic carbon content due to addition of organic matter through manures than fertilizers alone.[7, 8, 9] Addition of manures, *insitu* decomposition and green manure incorporation is attributable to increased soil microbial activity as observed in this study. Lowest organic carbon content in farmers practice is due to imbalanced nutrition with low biomass both root and shoot. With increasing ratooning, increasing trend in organic carbon was observed from its initial value of 0.54 to 0.80 %, it might be due to less disturbance of soil reduces the loss of oxidizable carbon and continuous addition of root biomass to the soil will increase the soil organic carbon content. Application of sugarcane trash @ 3t/ha in combination with fertilizer nitrogen significantly increased the organic carbon, available P and K, infiltration rate and moisture retention in the soil over no trash.[9] Integrated use of organics with inorganic fertilizers facilitated the accumulation of organic carbon which in turn had significant increment effect on the soil carbon pool and fertility status (N, P, K and S) of soil with reduction in bulk density beneficial for sustaining productivity of sugarcane plant-ratoon system.[10] Thus, application of either 100% NPK along with compost with biological enrichment @ 20 t/ha or 100% NP along with bio-methanated distillery effluent 150 m^3/ha (supplying 100% K) improved the fertility of soil and productivity of sugarcane plant-ratoon system.

Cane and Sugar Yields

Yields were increased with increasing levels of nitrogen up to 150 % recommended dose. During first year highest cane yields were recorded with 200 % mineral nutrients through fertilizers and at par with 150 % fertilizers, whereas during second year yields of 75.10 and 9.52 t/ha of cane and sugar yields were recorded with 150 % fertilizer nitrogen, however it was at par with 200 % fertilizer nitrogen and 100 % NPK fertilizers + hormonal spray of gibberilic acid. The increase in cane yield with increase in nitrogen application in sugarcane was due to the increase in yield attributing characters of sugarcane. At par results with hormonal spray is due to number of milleable canes at harvest and shoot population at formative phase was highest in this treatment. Significantly lowest cane and sugar yields were recorded with farmers practice. Integrated nutrient management treatments i.e 75 % recommended dose of fertilizer nitrogen + organics and 50 % recommended dose of fertilizer nitrogen + organics recorded at par yields with 100 % fertilizer nitrogen, but they could not meet the nutrient requirement as they recorded significantly lower yields than 150 % nitrogen fertilizers. Sugar yields also followed the same trend, as they are derivatives of the cane yield. Application of 150 kg N/ha for the plant and 225 kg N/ha for the ratoon crops is required for highest cane yield and net return over without fertilizers.[11,12]

Conclusion

A judicious combination of inorganic and organic is a potential tool for sustaining the soil fertility in sugarcane multiratoon. It can be summarized that inclusion of different organic sources and need based nutrient supply through foliar spray in sugarcane multi-ratoon system enhanced the soil organic carbon and microbial activity but also adequately met the nitrogen requirement leading to at par yields as with 100 % recommended fertilizers.

Table 1: Dehydrogenase activity (µg TPF/gm soil/day) under sugarcane multiratooning at different growth stages

Treatment	Azosprillium				Azotobacter			
	Initial	Formative	Grand growth	Harvest	Initial	Formative	Grand growth	Harvest
T1: 100 % RDF	7	9	5	3	2	5	3	0
T2: 75 % RDFN + KNO_3 @ 1% foliar spray + cane trash insitu decom.	8	20	9	10	0	6	2	2
T3: 50 % RDFN + 25 % N though vermi compost + green manure incorp	7	18	10	6	2	8	3	2
T4: 150 % RDFN	6	10	5	4	1	3	2	1
T5: 200 % RDFN	7	15	6	3	2	3	1	0
T6: Farmers Practice (only N as initial dose, no stubble shaving and no inter cultivation)	5	11	6	3	2	4	1	1
T7: 100 % RDFN + GA spray	6	12	4	2	1	2	2	0
Mean	6	12	4	2	1	2	2	0
CD (5 %)	NS	1.05	0.65	NS	NS	0.25	NS	NS

Table 2: Nitrogen fixing bacterial population (X 10^4 cfu/g soil) under sugarcane multiratooning at different growth stages of sugarcane

Treatments	Initial	Formative	Grand growth	Harvest
T1: 100 % RDF	1.55	2.72	1.59	1.42
T2: 75 % RDFN + KNO_3 @ 1% foliar spray + cane trash *insitu* decom.	1.46	3.89	2.25	1.8
T3: 50 % RDFN + 25 % N though vermicompost + green manure incorp	1.60	4.12	1.7	1.68
T4: 150 % RDFN	1.55	2.97	1.35	1.3
T5: 200 % RDFN	1.60	2.28	1.6	1.39
T6: Farmers Practice (only N as initial dose, no stubble shaving and no inter cultivation)	1.68	2.44	1.54	1.45
T7: 100 % RDF + Hormonal spray	1.52	2.57	1.55	1.6
Mean	1.57	3.00	1.65	1.52
CD (5 %)	NS	0.15	0.06	NS

Table 3: Effect of different nutrient management practices on phosphorus solubilizing bacteria ($X\ 10^3$ cfu/g soil) under sugarcane multiratooning at different growth stages of sugarcane

Treatments	Initial	Formative	Grand growth	Harvest
T1: 100 % RDF	0	3	1	1
T2: 75 % RDFN + KNO_3 @ 1% foliar spray + cane trash insitu decom.	2	5	2	1
T3: 50 % RDFN + 25 % N though vermi compost + green manure incorporation	1	4	2	2
T4: 150 % RDFN	1	2	1	0
T5: 200 % RDFN	2	5	2	1
T6: Farmers Practice (only N as initial) dose, no stubble shaving and no inter cultivation	1	6	2	2
T7: 100 % RDFN + GA spray	0	2	1	1
Mean	1.0	3.9	1.6	1.1
CD (%)	NS			

Table 4: Total bacterial and actinomycetes population ($X\ 10^6$ cfu/g soil) under sugarcane multiratooning at different growth stages of sugarcane

	Azosprillium		Azotobacter	
Treatments	Formative	Grand growth	Formative	Grand growth
T1: 100 % RDF	12	7	50	26
T2: 75 % RDFN + KNO_3 @ 1% foliar spray + cane trash insitu decom.	15	10	40	30
T3: 50 % RDFN + 25 % N though ver micompost + green manure incorp	18	11	60	42
T4: 150 % RDFN	15	10	45	22
T5: 200 % RDFN	12	9	60	31
T6: Farmers Practice (only N as initial dose, no stubble shaving and no inter cultivation)	7	5	42	18
T7: 100 % RDFN + GA spray	9	6	55	20
Mean	9	6	55	20
CD (5 %)	1.10	0.54	3.1	2.2

Table 5: Cane and sugar yield under sugarcane multiratooning

Treatments	Cane yield (t/ha)						Sugar yield (t/ha)					
	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
T1	59.60	70.50	69.38	69.05	66.47	68.70	7.72	9.33	10.60	9.13	8.65	8.63
T2	61.78	71.32	67.66	68.10	65.74	66.14	7.48	9.31	10.50	9.15	8.71	7.78
T3	60.59	69.97	65.87	65.22	62.81	64.50	7.77	9.35	10.54	8.49	8.32	7.98
T4	66.13	75.10	75.66	71.43	69.38	72.24	8.33	9.52	11.31	9.76	8.69	8.72
T5	68.71	74.80	77.38	73.05	72.35	73.75	8.62	9.43	10.70	9.27	9.02	8.61
T6	56.60	61.20	65.41	63.30	65.54	8.57	7.19	8.16	9.20	8.19	8.68	8.19
T7	62.77	73.43	71.23	69.80	66.86	63.12	7.93	9.62	10.99	8.85	8.79	7.59
Mean	62.31	70.90	70.37	68.56	67.06	68.15	7.86	9.25	10.55	8.97	8.71	8.22
CD .5 %)	NS	5.80	NS	6.10	4.20	4.50	0.68	NS	0.49	0.54	NS	0.48

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Conflict of Interest

The authors do not have any conflict of interest.

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