Effects of organic amendments on earthworm population in sugarcane plant ratoon system under different planting methods

ABSTRACT

This research aimed to study the effect of organic sources under different planting methods on the population of earthworm in sugarcane plantation for plant and ratoon crop. The experiment was conducted at Regional Agricultural Research station, Anakapalle (Andhra Pradesh) on sandy loan soils under split split plot design with different planting methods, soil health management practices and nutrient levels. The main plots consisted of three planting methods M_1:conventional planting, M_2: paired row planting, M_3: dual row planting along with four organic amendments as sub plots (Control, trash mulching + biodecomposer (A & B), green manuring with sunnhemp @ 37.5 kg ha^{-1} seed rate, green manuring with sunnhemp @ 25 kg ha^{-1} seed rate followed by intercropping) and two nutrient levels as sub sub plots (75% RDF + NPK biofertilizers and 100% RDF). The results showed that in the plant and ratoon crop significantly highest earthworm population was observed with green manuring with sunnhemp @ 25 kg ha^{-1} seed rate followed by intercropping and was found significantly superior to control treatment.Organic sources can improve both the physicochemical and biological properties of the soil under these conditions, which cousld improve soil ecosystem services and thus increasing the earthworm population.

Key words: Sunnhempgreenmanuring, Plant-ratoon system, RDF, Sugarcane, Greengram intercropping, Planting methods, Earthworm population.

INTRODUCTION

Sugarcane(*Sachharumsofficinarum* L.) is an important cash crop globally not only for sugar production, but also as bio energy crop due to its phenomenal drymatter producing capacity which belongs to Gramineace family(Moneda et al, 2022). It is also called as 'wonder cane' due to its multifaceted utility and the vast capability to encounter the demands of the increasing population Sugar industry being the second largest agro-based industry next to textile industry, plays a dominant role in both agricultural and industrial economy of our nation. It employs over 50 million cane growers and about 5.0 lakhs skilled and unskilled workers (NITI Aayog, 2020).

Continuous application of inorganic fertilizers in a monoculture system of sugarcane plantation may accelerate soil degradation by decreasing soil organic matter. Organic amendment of agricultural soil can contribute to carbon sequestration and can enhance soil biodiversity by improving the quality and quantity of nutrients available for soil organisms(Viketoft et al.2020).

Earthworms are important soil biota that can be used as indicators of soil fertility. In soil, earthworms represent the largest component of the animal biomass and are commonly termed as ecosystem engineers (Blouin et al. 2013). Earthworms play an important role in improving soil physical properties, namely in the decomposition of fresh organic matter and mixing the organic decay with soil particles, so that the soil particles will be aggregated and hence will improve soil structure (Buck et al. 1999 and Fonte et al. 2010). Earthworms also improve soil aeration and improving soil porosity by making holes. In addition, earthworms

can improve nutrient availability by their role in the process of decomposition and mineralization of organic.

A study on influence of organic amendments on earthworm populations was felt essential in sugarcane system so the experiment was conductedInfluence of organic sources on earthworm population in sugarcane plant-ratoon system under different planting methods was conducted.

MATERIALS AND METHODS

2.1 Experimental site

The field experiment was carried out during the 2022–23 to 2023–24 at Regional Agricultural Research Station, Anakapalle , Andhra Pradesh with precise coordinates of on 18°45' N latitude and 83°01' E longitude and at an altitude of 28.62 m above the mean sea level and about 22 km away from Bay of Bengal. The study area has a subtropical, hot and humid environment with a mean annual rainfall of 1,010 mm. Between July and September, 75–80% of the rain occurs. There were significant patterns of rainfall variability during the 2 years of the experiment, both in terms of amount and distribution. The mean maximum and minimum temperatures, relative humidity and rainfall during the harvest period are presented. The total rainfall was 1,059 mm (2022– 23), 957 mm (2023–24). The weekly mean maximum temperature ranged from 29.6 to 37.9°C and 28.4°C to 41.7°C during 2022-23 and 2023-2024, respectively and the weekly mean minimum temperature for the corresponding period ranged from 14.2°C to 26.2°C and 16.9°C to 28.8°C, Accordingly, weekly relative humidity for F. N and A. N were 86 and 73 per cent during 2022-23 and 86 and 61.0 per cent during 2023-24, respectively.

2.2 Experimental design and treatment details

This trial was conducted in a sugarcane plant-ratoon system and included three planting methods, four soil health management practices and two nutrient levels with three replications. Planting methods: conventional planting with 90 cm row spacing, paired row planting with 60:150 cm row spacing, dual row planting with 30:150 cm row spacing; soil health management practices: control,trash mulching + biodecomposer (A & B), green manuring with sunnhemp @ 37.5 kg ha^{-1} seed rate, green manuring with sunnhemp @ 25 kg ha^{-1} seed rate followed by intercropping; nutrient levels: 75% RDF + NPK Biofertilizers and 100% RDF similar treatments were followed in case of ratoon crop.

2.3 Crop management

Prior to cultivation, the experimental site was cleared, plowed, and harrowed manually. The gross plot size was 9 m × 3.75 m (33.75 m^2) and the net plot size varied according to planting methods i.e., was 5.4 m × 3.75 m (20.25 m^2) in conventional row method, 4.2m × 3.75 m (15.75 m^2) for paired row method of planting and 5.4 m × 3.75 m (20.25 m^2) in dual row. Sugarcane variety "2009 A 252"- "Naveen" variety was planted on 25thFebruary, 2022 40,000 three budded setts ha^{-1} . Before planting, the cane setts were

treated with 0.3% Mancozeb 75% WP and 1.7 % of Monocrotophos 36 % SL solution to protect them from insect and disease attack. The chemical fertilizer amounts of N, P_2O_5, and K2O were used as 168:100:120 kg N, P, and K ha^{-1} in the plant crop and 336 N: 100 P_2O_5: 120 K_2O kg ha^{-1}in the ratoon crop, respectively.

SSP and muriate of potash (MOP) were used to supply P and K which were applied as basal in plant crop. Sugarcane was topdressed with urea in two equal splits *i.e.,* at 45 DAP and 90 DAP as a source of nitrogen.Whereas in ratoon crop entire dose of phosphorus, potash and half dose of nitrogen were applied at time of ratoon initiation and remaining nitrogen was applied at 45 DAR.

In accordance with the treatments, sugarcane trash of 3 t ha^{-1} was applied 3 days after planting and applied trash was treated with Bio- decomposing culture *viz.,* bio-decomposer A and bio-decomposer B developed from Agricultural Research Station, Amaravathi, ANGRAU and in case of ratoon entire trash from plant crop was applied after shredding with tractor drawn shredder.Sunnhemp (*Crotalaria juncea)* of local variety was grown as intercrop between 2 rows of sugarcane and green manuredin situ in the soil at 45 DAS and in the second year it greenmanure was sown immediately after ratoon initiation.After incorporation of sunnhempgreengramsowning was done in between sugarcane rows and the biomass was incorporated after pod picking.To compare earthworm abundance for specific treatment combinations, one square metre area (1x1 m) was manually excavated in each treatment at formative, grand growth and harvest stages of both plant and ratoon crop. The excavated soil was carefully hand sorted for earthworms and data was recorded and expressed in number of earthworm per square metre of soil. Finally, the data was analysed by using Analysis of Variance (ANOVA) was performed using standard procedure for split-split plot design.

RESULTS AND DISCUSSION

Earthworms play an important role in soil health and represent a large proportion of soil organism biomass and have an important agro-ecological functions since they influence organic matter dynamics and soil structure (Leroy *et al.* 2008). Earthworms may be used as bioindicators of soil management because they are very sensitive to both chemical and physical soil parameters.

Earthworm abundance data recorded at formative, grand growth and harvest stages showed a clear significant response to different soil health management practices while the nutrient levels and planting methods had no significant effect on earthworm individuals (Table 1). However, most of the earthworms collected were juveniles at all the stages in both the years of experimentation.

At formative stage of sugarcane the larger earthworm population was observed under *in situ*sunnhemp green manuring in interrows of sugarcane followed by greengram intercropping and incorporation (S_4) with 43.98 and 32.56 m^2 individuals in plant and ratoon crop, respectively which were found significantly higher over other treatments. The next followed treatments were *in situ*sunhmep green manuring (S_3) and trash mulching with

biodecomposer (S_2) and maintained significant superiority over control treatment where no soil health management practices were followed.

Similarly, significantly higher earthworm populations (39.32, 12.29 and 25.80, 22.66 m^2 individuals in plant and ratoon crop, respectively) at grand growth and harvest stages was recorded with S_4 treatment (Green manuring with sunnhemp @ 25 kg ha^{-1} f.b. intercropping with greengram) which was found on par with S_3 (Green manuring with Sunnhemp @ 37.5 kg ha^{-1}) and S_2 (Trash mulching + biodecomposer A & B) treatments. Whereas lowest earthworm population at all growth stages was observed in case of control plot. The increase in earthworm abundance in the plots receiving organic amendments can be attributed to the higher organic carbon content of these plots and may also protect earthworm populations by improving the soil moisture retention and providing a more favourable habitat for earthworms. Similar results were observed by Singh *et al*. (2010a) and Nurhidayati*et al.* (2012).

The increased earthworm population in green manured plots compared to trash mulching might be due to the lower C:N ratio and low liginin content of green manure compared to sugarcane trash. It has been found that earthworms remove organic materials with a lower C:N ratio preferentially. Similar reports were given by Whalen *et al*. (1998). However, the interaction effect between planting methods, soil health management practices and two doses of nutrient levels on earthworm population was found to be non-significant.

Conclusion

Thus, the addition of organic sources is recommended in the sugarcane land management for maintaining the existence and activity of earthworms. From the study it can be concluded that green manuring with sunnhemp @ 25 kg ha^{-1} f.b. intercropping with greengram proved to be best soil health management practice for improving the earthworm population in the soil and in turn an important factor in the improvement of soil health in sugarcane plant-ratoon system.

Table 1.Earthworm population at different growth stages as influenced by planting methods, soil health management practices and nutrient levels in plant and ratoon cropsof sugarcane

Treatments	Earthworm population (no. m^2)					
	Plant crop			Ratoon crop		
	120 DAP	240 DAP	At Harvest	120 DAP	240 DAP	At Harvest
Planting methods						
M_1: Conventional planting (90 cm)	39.50	36.75	10.17	30.79	23.47	18.55
M_2: Paired row planting (60/150 cm)	38.12	37.33	11.07	30.76	24.2	17.77
M_3: Dual row planting (30/150 cm)	39.50	35.22	11.56	30.05	23.6	18.97
S.Em±	1.07	0.85	0.32	0.57	0.45	0.369
CD (p = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	13.4	11.4	14.2	9.1	9.3	10.2
Soil health management practices						
S_1: Control	31.93	32.00	8.26	27.6	20.15	13.53
S_2: Trash mulching + biodecomposer (A & B)	38.93	36.71	11.57	30.79	24.42	17.65
S_3: Green manuring with sunnhemp @ 37.5 kg ha^{-1} seed rate	41.31	37.70	11.61	31.18	24.66	19.88
S_4: Green manuring with sunnhemp @ 25 kg ha^{-1} seed rate f.b. intercropping with greengram	43.98	39.32	12.29	32.56	25.8	22.66
S.Em±	0.84	0.89	0.27	0.64	0.51	0.4
CD (p = 0.05)	2.50	2.63	0.79	1.91	1.51	1.18
CV (%)	9.2	10.3	10.2	8.9	9	9.1
Nutrient levels						
F_1: 75% RDF + NPK Biofertilizers (*Azosporillum* + PSB + KRB each @ 1250 ml ha^{-1})	38.94	36.10	11.09	30.39	23.74	18.49
F_2: 100% RDF	39.14	36.77	10.78	30.68	23.78	18.37
S.Em±	0.60	0.54	0.16	0.36	0.24	0.25
CD (p = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	9.1	8.9	8.8	7.08	5.9	8.0
Interaction						
M x S	NS	NS	NS	NS	NS	NS
M x F	NS	NS	NS	NS	NS	NS
S x F	S	NS	NS	NS	NS	NS
M x S x F	NS	NS	NS	NS	NS	NS

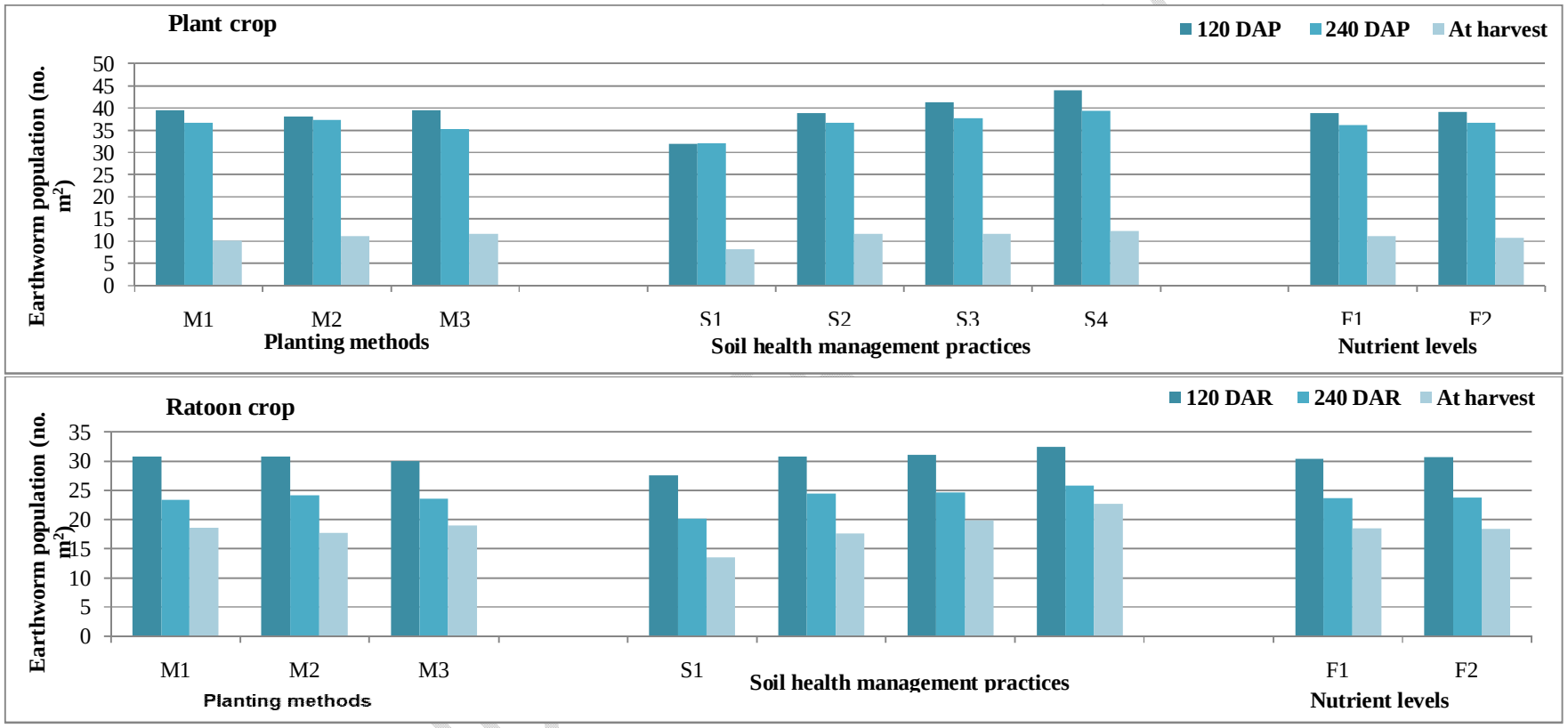

Fig.1 Earthworm population at different growth stages as influenced by planting methods, soil health management practices and nutrient levels in plant and ratoon cropsof sugarcane

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Reference

Blouin M, ME Hodson, EA Delgado, G Baker, L Brussaard, KR Butt, J Dai, L Dendooven, G Peres, JE Tondoh, D Cluzeau and JJ Brun . 2013. A review of earthworm impact on soil function and ecosystem service. Eur J Soil Sci 64: 161-182.

Buck C, M Langmaack and S Schrader. 1999. Nutrient content of earthworm cast influenced by different mulch types. Eur J Soil Biol 35: 23-30.

Fonte, S.J., Barrios, E. and Six, J. 2010. Earthworm impacts on soil organic matter and fertilizer dynamics in tropical hillside agroecosystems of Honduras. *Pedobiologia*. *53*(5): 327-335.

ISMA, 2022.Percentage of sugarcane production utkized for variours purpose.*Cooperative sugar*.53: 45.

Leroy, B.L., Schmidt, O., Van den Bossche, A., Reheul, D and Moens, M. 2008. Earthworm population dynamics as influenced by the quality of exogenous organic matter. *Pedobiologia*. 52 (2): 139-150.

Moneda, A.P.C., de Carvalho, L.A.L., Teheran-Sierra, L.G., Funnicelli, M.I.G and Pinheiro, D.G. 2022. Sugarcane cultivation practices modulate rhizosphere microbial community composition and structure. *Scientific Reports*.12 (1): 19174.

Nurhidayati, N., Arisoesilaningsih, E., Suprayogo, D and Hairiah, K. 2012. Earthworm population density in sugarcane cropping system applied with various quality of organic matter. *Journal of Tropical Life Science*. 2 (3): 103-109.

Singh, A.K., Singh, S., Rao, V.V., Bagle, B.G and More, T.A. 2010a. Efficacy of organic mulches on soil properties, earthworm population, growth and yield of aonla cv. NA7 in semi-arid ecosystem. *Indian Journal of Horticulture*. 67 (4): 124-128.

Viketoft, Maria, Laura GA Riggi, Riccardo Bommarco, Sara Hallin, and Astrid R. Taylor. 2021. Type of organic fertilizer rather than organic amendment per se increases abundance of soil biota.*PeerJ 9*: 11204.

Whalen, J.K., Parmelee, R.W and Edwards, C.A. 1998. Population dynamics of earthworm communities in corn agroecosystems receiving organic or inorganic fertilizer amendments. *Biology and Fertility of Soils.* 27: 400-407.