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Impact of various cropping systems and organic integrated nutrient management on earthworm population under rainfed condition

PV Shingrup, AN Paslawar, BV Saoji, VM Bhale, DV Mali and YV Ingle

Abstract
A field experiment was conducted during kharif season of 2018-19 and 2019-20 at Centre for Organic Agriculture Research and Training field, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The results after experiment indicated that, various cropping systems and additions of nutrients through organic nutrient sources with alone and in combination were significantly influenced population of earthworms. Among, various cropping systems mean earthworm population per plot and per hectare was significantly highest in blackgram – chickpea followed by cotton + pigeonpea (3:1) but found at par with blackgram – rabi sorghum rotated with cotton + sunhemp (GM) and pigeonpea + soybean (1:4) rotated with cotton + blackgram (2:1). While in nutrient management combination of 75% organic integrated nutrients through FYM and vermicompost (top dressing) + 25% through neem cake recorded significantly highest mean earthworm population over other OINM.

Keywords: Various cropping systems, organic integrated nutrient management, earthworm population, rainfed condition

Introduction
Organic agriculture is a production system that sustains the health of soil, surrounding ecosystem and people. It relies on ecological processes, biodiversity and cycles adapted to local condition rather than the use of inputs with adverse effect. Organic agriculture combines tradition, innovation and science to benefit the shared environment with fair relationship and good quality of life for all involved. Unlike chemical farming, organic farming aims to "feed the soil" rather than "feed the plant". It means giving back to the nature what has been taken from it. Since organic farming aims to maintain soil health and to obtain highest yield in a sustainable and ecofriendly manner on the long term basis.

Crop rotation is one of the important practices known to reduce infestation of insect pests, disease and weeds. This system not only provides organic matter to the soil but also proved to be profitable cropping system. But continuous growing of any crop or cropping system may leads to increase the intensity of pest, disease and weeds. To break their life cycle, crop rotation is must. Crop rotation affects, the insect population by altering the microclimate or by encouraging the natural enemies of the insect pest in the system. Inclusion of legumes in the cropping system is very effective not only from the point of nitrogen fixation but judicious utilization of soil nitrogen also.

Generally, in organic farming most of the sustainable practices are used, like crop residue retention on the soil surface, intercropping, green manuring mulching and integration of crops and livestock are not alien to agriculture systems including the traditional agriculture practices (Awasthe *et al*. 2017) [1] which prohibit the use of synthetic inputs and the central theme of this method is the health of soil and preventing degradation of natural resources. Demand of organic food and fibre is increasing globally and there is need for innovative farming practices to improve soil health so that food and fibre production resilience may be ensured.

Earthworms are an important organism in the soil doing great service for mankind for millions of years now. It combines immense social, economic and environmental values together which is now being realized and recognized. Earthworms are often referred to as farmer's friends and nature's ploughmen. Earthworms are natural ploughers of the soil throughout day and night, maintaining the fertility and porosity of the soil. Earthworms play a key role in the biology of soil as versatile natural bioreactors. The earthworms, work as "fine drainage maker", which not only improve the water and air circulation in the soil, but also mixing of organic and

mineral substances. During their feeding, they promote increased microbial activity, which in turn accelerates the breakdown of organic matter and stabilization of soil aggregates. Earthworms degrade all types of organic wastes such as agricultural wastes, animal droppings, weeds, forest litter and agro-industrial wastes, favour faster development of worms and eventual compost production. Earthworms play a vital role in converting organic wastes to useful vermicompost. The dead worm's tissue discharges nitrogen in form of nitrates 25%, ammonia 45%, organic soluble compound 3% and other material 27%. Also, they feed on dead organic substances present in soil that is ingested together and after digestion, along with the undigested food is finally egested in the form of worm casting. Though the different nutrient sources which are applied in alone and in combination had been given due importance, the perfect combination on which population of earthworm were recorded to be maximum yet to be quantified. Hence present investigation was carried out to assess the average population of earthworm under organic cultivation on various cropping system under rainfed condition of Vidarbha region.

Methodology

The experiment was conducted on organically certified field at Centre for Organic Agriculture Research & Training (COART), Department of Agronomy, Dr. PDKV, Akola, Maharashtra during *kharif /rabi* season of 2018-19 and 2019-20 with the objective to assess the impact of various cropping system rotation and nutrient modules on productivity and *in-situ* biomass addition and soil fertility. The experiment was laid out in strip plot design with main plot consist of six cropping systems viz. cotton (sole), pigeonpea + soybean (1:4), blackgram – *rabi* sorghum, pigeonpea + foxtail millet (1:4) and blackgram – chickpea, rotated with pigeonpea + soybean (1:3), cotton + blackgram (2:1), cotton + sunhemp (GM), cotton sole and cotton + pigeonpea (3:1) and rotated every year for the maintenance of soil health and pest distraction. Sub plot consist of organic integrated nutrient management viz. organic package for each crop 100% RDN through equivalent organic sources i.e. FYM and vermicompost (top dressing), integrated nutrient management (IONM) 75% through FYM and vermicompost (top dressing) + 25% through neem cake and control (No manure). Phosphorus amount in the experiment as per RDF was adjusted through phosphorus rich organic manure (PROM). Sowing was done on broad bed furrow system for conservation of moisture. Sowing was done in last week of June in both years. Application of *Trichoderma, Rhizobium and PSB* was done in all crops as seed treatment. Plant protection schedule was followed organically (IPM practice). The *in-situ* biomass conservation was done though tractor drawn shredder after main produce taken out on same plot for maintenance of soil health. The cotton equivalent yield and biomass addition through various cropping system were worked out. The initial organic carbon content was 4.40 g/kg of soil and NPK was 193.68, 14.61 and 323.99 kg/ha. Rainfall of season was 834 and 929 mm respectively with 42 and 57 rainy days during experimentations.

Earthworm count was taken when soil moisture was sufficient from one square meter area and from 30 cm depth of five observation randomly selected plants from each plot by removing deep block of soil and earthworms were counted by hand during both the years and then converted on hectare basis. The development stage of each earthworm was noted and return earthworms to the soil pit and backfill with soil (Céline Pelosi *et al*. 2009) [3].

Results

Population of earthworms counted in square meter area at 30 cm depth at flowering stage of crops from each treatment and then converted into hectare area and mean was work out for both the years under study. Data pertaining to earthworm population as influenced by different treatments are presented in below Table and shown in fig.

A. Cropping sequence

In first year, blackgram – chickpea sequence cropping recorded significantly highest earthworm population meter square^{-1} and hectare^{-1} at 30 cm depth over sole cotton, but found statistically at par with all cropping system under study, closely followed by pigeonpea + soybean (1:4) intercropping system. This might be attributed to inclusion of legume crop in inter or sequence cropping which keeps soil covers throughout the growing period resulted in increased soil rhizosphere activity and moisture availability. Also sowing on broad bed furrow helps in good establishment of all crops and roots which has harmonizing effect on earthworm population.

In second year, cotton + sunhemp (GM) documented significantly highest earthworm population meter square^{-1} and hectare^{-1} at 30 cm depth over sole cotton but found on par with all cotton based intercropping system and pigeonpea + soybean intercropping system. Enhancement in earthworm population at grand growth stage might be due to the fact that *in-situ* green manuring of sunhemp and addition of biomass in intercropping which serve as food and energy for earthworm and in turn advanced earthworm population. However, the lowest earthworm population was documented in cotton rotated with cotton over other crop sequences under study.

Pooled data of both years revealed that significantly higher earthworm population was observed in blackgram – chickpea followed by cotton + pigeonpea (3:1) but found at par with blackgram – rabi sorghum rotated with cotton + sunhemp (GM) and pigeonpea + soybean (1:4) rotated with cotton + blackgram (2:1). This clearly indicates the importance of soil cover throughout the crop period by virtue of intercropping or sequence cropping and also more availability of left over biomass which act as feed for earthworm and moisture availability for their activity over cotton - cotton sequence. Similar findings were reported by Bilalis *et al*. (2009) [2], Delgado *et al*. (2012) [4] and Gadelha *et al*. (2014) [7].

B. Organic integrated nutrient management

During both years of study, significantly advanced earthworm population was observed with 75% FYM + Vermicompost (topdressing) + 25% Neem cake at grand growth stage of crops over other organic integrated nutrient management treatments. The most important feature of vermicomposting (applied as top dressing) is that, during the processing of various organic wastes by earthworms, it fragments the substrate and thereby increases the surface area for further microbial colonization. The enhanced microbial activities accelerate the decomposition process leading to humification, thus oxidizing unstable organic matter in to stable form. During the passage through the gut of earthworms, the surviving microorganisms are voided along with cast. Thus, vermicompost not only provides mineral nutrients to soil, but also contributes to the biological fertility factor by adding beneficial microbes to the soil and moisture maintained due to

sowing on broad bed furrow and intercropping system. Also, neem seed cake as a form of organic manure on decomposition, promotes an increase in soil microbial communities along with earthworms and this in turn will affect the growth and yield of crop. Similar results were recorded by Edwards and Bohlen (1996) [6], Leroy *et al.* (2008) [9], Duong (2013) [5] and Jadhav *et al.* (2021) [8].

Table 1: Mean number of earthworms meter square^{-1} and hectare^{-1} at 30 cm depth as influenced by different cropping systems and organic integrated nutrient modules during 2018-19 and 2019-20.

Treatments	No. of earthworms meter square^{-1} at 30 cm depth		Pooled per square meter	No. of earthworms hectare^{-1} at 30 cm depth		Pooled per square meter
Main Factor	2018-19	2019-20		2018-19	2019-20	
A) Cropping system						
T1 – Cotton *fb* PP + Soy (1:3)	1.14	2.44	1.79	11411	24411	17911
T2 - PP + Soy (1:4) *fb* Ct + BG (2:1)	1.38	2.34	1.86	13778	23400	18589
T3 - BG – Sorg *fb* Ct + GM (2:1)	1.33	2.51	1.92	13278	25056	19167
T4 - PP + FM (1:4) *fb* Cotton	1.34	1.97	1.66	13400	19711	16556
T5 - BG – Chickpea *fb* Ct + PP (3:1)	1.42	2.45	1.93	14178	24456	19317
T6 – Cotton *fb* Cotton	1.20	1.85	1.53	12011	18544	15278
SE(m)±	0.04	0.07	0.04	449	687	404
CD at 5%	0.14	0.22	0.13	1416	2166	1272
Sub factor						
B) OINM						
N1 – FYM + VC	1.29	2.35	1.82	12917	23517	18217
N2 – FYM + VC + NC	1.46	2.54	2.00	14567	25367	19967
N3 – Control	1.14	2.06	1.60	11417	20550	15983
SE(m)±	0.03	0.04	0.01	313	380	113
CD at 5%	0.12	0.15	0.04	1230	1493	443
Interaction (AXB)						
SE(m)±	0.08	0.10	0.08	775	1047	774
CD at 5%	NS	NS	NS	NS	NS	NS
GM	1.30	2.26	1.78	13009	22596	17803

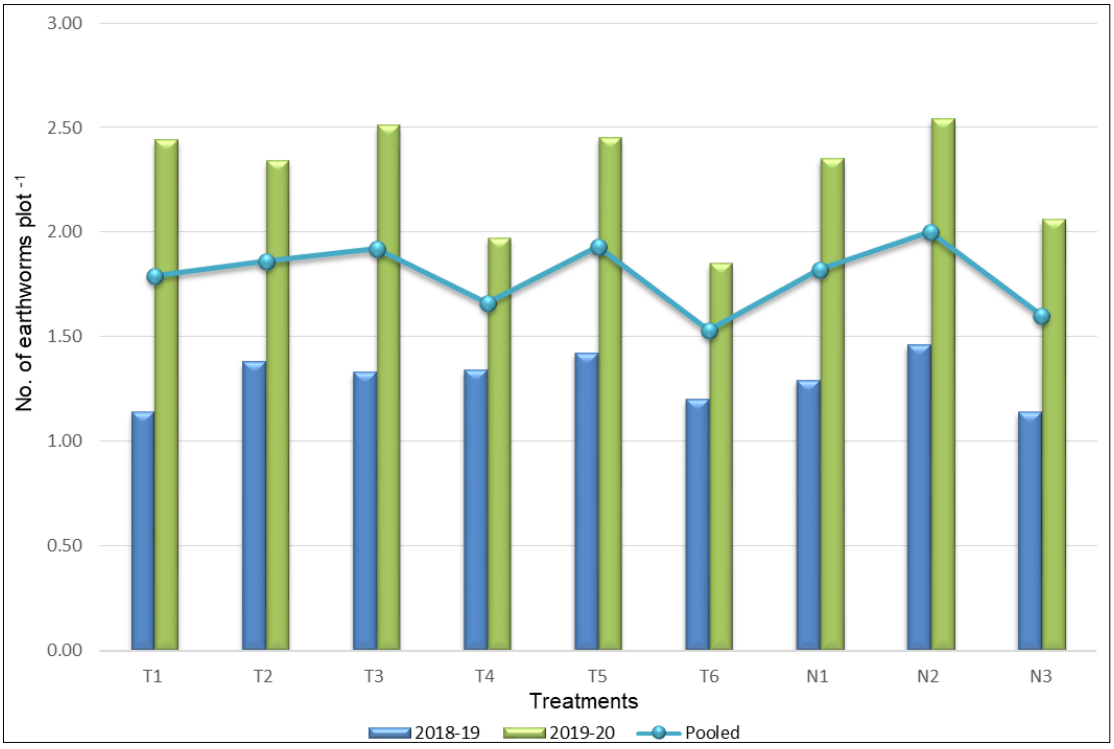

Fig 1: Mean number of earthworms meter square^{-1} as influenced by different cropping systems and organic integrated nutrient modules during 2018-19 and 2019-20

C. Interaction

Interaction effect was found non significant.

Conclusion

Among, various cropping systems mean earthworm population per plot and per hectare was significantly highest in blackgram – chickpea followed by cotton + pigeonpea (3:1) but found at par with blackgram – rabi sorghum rotated with cotton + sunhemp (GM) and pigeonpea + soybean (1:4) rotated with cotton + blackgram (2:1). While in nutrient management combination of 75% organic integrated nutrients through FYM and vermicompost (top dressing) + 25% through neem cake recorded significantly highest mean earthworm population over other OINM.

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