Short communication

Organic amendments and their impact on arthropod diversity in rice (*Oryza sativa* L.) fields of Hyderabad, India

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Abstract

Organic manuring influences the diversity of arthropods and their functional significance in rice fields. Arthropod diversity under eight organic manure regimes consisting of farmyard manure (FYM), vermicompost (VC), poultry manure (PM), neem cake (NC), FYM + 50% recommended fertilizer dose (50%RFD), VC+50% RFD, RFD, and unfertilized control (UC) was assessed in a randomized block design experiment. The doses of organic amendments were adjusted to give the recommended level of 120 kg N ha^{-1}. Arthropod sampling was carried out by sweep-nets, vacuum sampling, and straining. Higher abundance of arthropods was observed in plots treated with VC and NC with the spider *Tetragnatha* sp. being the dominant species. Simpson's index indicated that the maximum diversity was observed in PM treated plots (0.022) while the least was in RFD plots (0.183).

Keywords: Vermicompost, Poultry manure, Neem cake, Predator, Parasitoid, Phytophage, Diversity indices

Although the Green Revolution has lead to a tremendous increase in food grain production in South Asia, it has polluted and exhausted the soil. Several long-term field experiments indicated a declining trend in grain yield under intensified rice cropping with constant and high fertilizer inputs (Dawe et al., 2000). Organic farming aims at avoiding synthetic agrochemicals and was found to significantly improve the soil physical properties, fertility, and biological properties. In addition to improving soil health, organic farming systems also enhance species richness (Hole et al., 2005). In particular, ground beetles and spiders, important generalist predators, increased in the organically treated fields (Pfiffner and Luka, 2003). In a crop like rice, having aquatic, benthic, and arboreal niches, a complexity of biota interact with one other (Gangurde, 2007) and provides scope for natural biological control through community level interactions (Savary et al., 2012). Reduction in pests under organic manuring will further help to reduce insecticide use. But studies on biodiversity in rice with special reference to organic amendments is lacking. In particular, there is a need to study the effect of organic manuring on arthropod diversity and its impact on pests, since an important ecological implication of biodiversity is reduced pest incidence through natural control. Hence the present study was carried out to assess arthropod diversity under various regimes of organic manure applications and its impact on pest incidence.

The study was carried out in an irrigated rice field ecosystem at the research farm in Hyderabad (17° 20' N and 78°24' E), belonging to the Telengana zone of Andhra Pradesh, India, during 2006–2008. The experiment was laid out in a randomized block design with eight treatments each with three replications having a single plot area of 21 m^2 and a total plot size of 510 m^2. The test variety was BPT

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5204. The treatments included: farmyard manure (FYM), vermicompost (VC), poultry manure (PM), neem cake (NC), recommended fertilizer dose (RFD) at 120 K N ha^{-1}, FYM + 50% RFD, VC+50% RFD and unfertilized control (UC). The doses of organic amendments were adjusted to give recommended levels of nitrogen (Table 1) while the phosphorous and potassium levels were kept constant. There was no application of insecticides in the experimental plots. All other cultural practices were as per standard recommendations. Observations were recorded at 10 day interval on pest incidence. The extent of damage by whorl maggot was assessed by counting the total number of leaves and the number of damaged leaves (DL) which showed the typical white streaks and bent tips. In the case of stem borer, the percentages of dead hearts (DH) and white ears (WE) were worked out by counting the total number of tillers and the number of DH at vegetative stage and total number of panicles and the number of WE at reproductive stage. The terrestrial arthropod fauna consisting of insects and spiders inhabiting the rice and the non-rice (bunds or risers) habitats were sampled using a suction device and a standard sweep net (10sweeps/plot). Aquatic insects were sampled by collecting water from random locations in the treated plots using a standard dipper and subsequent sieving (mesh size 160 mm) during the early crop growth phase from 15 days after transplanting to 45 days after transplanting. The insects collected were stored in vials in 70% ethyl alcohol. In the laboratory they were sorted to the lowest taxon possible (family, genus, or species). The functional groups of different species was determined from literature and also based on actual observations on feeding behaviour and mouthpart morphology. Richness, diversity, and evenness indices were calculated to assess arthropod diversity under different treatments, as described by Ludwig and Reynolds (1988).

Table 1. The fertilizer doses of various organic treatments of Hyderabad, India.

Treatments	% N	Amount applied (tonnes ha^{-1})
Farm yard manure (FYM)	0.60	20.00
Vermicompost (VC)	2.85	04.20
Poultry manure (PM)	2.95	04.05
Neem cake (NC)	4.80	02.50
Recommended fertilizer dose (RFD) (120Kg N ha^{-1})	46.0	00.13
Untreated control	–	00.00

The total abundance of arthropods and species diversity was highest in the VC applied plots (Fig. 1). Although abundance was next to maximum in UC, species diversity was only half of that in VC treatment. Increased species abundance in organically treated fields is expected and has been reported in earlier studies too (e.g., Bengtsson et al., 2005). The spider, *Tetragnatha* sp., was dominant in the VC and NC plots. Simpson's index was maximum for PM plots (0.022), while the least was observed in the RDF plots (0.183). Shannon's index and Margalef index (Table 2) were highest in NC (1.075) and PM (31.45) plots respectively. This is consistent with the observations of Gangurde (2007).

An analysis of the guild structure of arthropods

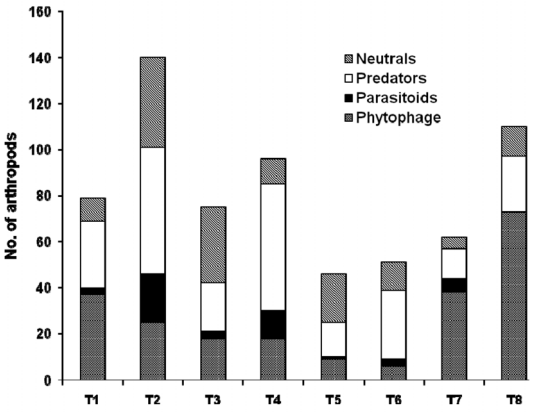

Figure 1. Arthropod guild structure in organically treated fields of Hyderabad, India (T1- Farmyard manure, T2-vermicompost, T3 -Poultry manure, T4- neem cake, T5-FYM + 50% recommended fertilizer dose, T6 - VC+ 50% recommended fertilizer dose T7 - Recommended Fertilizer dose and T8- untreated control).

Table 2. Biodiversity assessment of an organically treated rice field of Hyderabad, India.

Biodiversity indices	T1	T2	T3	T4	T5	T6	T7	T8
Shannon' s Index	1.07	1.15	1.06	1.08	0.84	0.89	0.69	0.89
Berger-Parker Dominance (d %)	14.29	20.51	14.29	23.53	26.67	23.53	31.25	20.00
Simpsons index (D)	0.07	0.07	0.02	0.09	0.11	0.10	0.18	0.12
Hill's Number H_0	14.00	19.00	12.00	17.00	8.00	9.00	6.00	9.00
Margaleff index	24.88	22.63	31.41	23.51	30.61	29.26	29.90	24.37

(T1- Farmyard manure, T2- vermicompost, T3 -Poultry manure, T4- neem cake, T5- FYM + 50% recommended fertilizer dose, T6 – VC+ 50% recommended fertilizer dose T7 - Recommended Fertilizer dose and T8- untreated control)

collected from various organically treated plots revealed that the phytophages observed were thrips, brown plant hopper, white backed planthopper, green leafhopper, whorl maggot, shootfly, yellow stemborer and leaffolder. The parasitoids included: *Tetrastichus shoenobii* Ferriere, *Xanthopimpla flavolineata* Cameron, pipenculids, and the mollusk parasitoid *Sepedon* sp. The predatory guild consisted mainly of coccinellids (*Micraspis discolor* (F.), *Coccinella transversalis* Fabricius, and *Harmonia octomaculata* Fabricius), damselflies (*Agriocnemis femina femina* Brauer), *Agriocnemis pygmaea* Rambur), and dragonfly (*Orthetrum Sabina* Drury), spiders (*Tetragnatha* spp, *Lycosa psuedoannulata* Boesenberg & Strand and *Araneus* sp.), green mirid *Cyrtorhinus lividipennis* Reuter and the predatory flies *Octhera* sp and *Condylostylus* sp. In VC plots, the predator guild was dominant followed by neutral insects (Fig. 1), whereas in the UC plot, though arthropod abundance was high it was mainly constituted by the phytophage guild. The predator numbers were also high in NC treated plots while the neutral insect population was high in PM plots.

Stem borer, *Scirpophaga incertulas* Walker was the key pest observed in the treated plots, followed by whorl maggot *Hydrellia* sp., which occurred early in the season. Stem borer incidence was significantly different among the treatments (Table 3) and showed that the dead hearts ranged from 13 to 22% while the white ears ranged from 2.0 to 3.7%. Lowest stem borer incidence was observed in NC treated plots (13.6 and 1.7% DH and WE respectively). Yield under various organic treatments did not differ statistically and the highest yield was recorded in

Table 3. Effect of organic manures on insect pest incidence and rice yields of Hyderabad, India.

	Whorl maggot incidence % DL		Stem borer incidence		Yield (kg/ha)
			% DH	% WE	
Treatments	25 DAT	35 DAT	65 DAT		
FYM	13.3^{e*}	2.8b^{c}	22.1^{d}	2.7^{ab}	3105
Vermicompost (VC)	3.0^{a}	2.4^{ab}	17.1^{b}	4.3^{c}	3080
Poultry manure	4.5^{b}	2.1^{abc}	17.0^{b}	2.8b^{c}	2767
Neem cake	6.8^{c}	1.9^{ab}	13.6^{a}	1.7^{a}	3863
FYM+50% N	13.0^{e}	2.7^{bc}	16.4^{ab}	3.7^{b}	3105
VC+50% N	7.7^{cd}	1.6^{a}	14.0^{a}	2.0^{a}	4405
RFD	9.2^{d}	2.0^{abc}	14.4^{ab}	1.6^{a}	4802
Untreated control	12.1^{e}	3.0^{c}	17.9^{c}	2.4^{ab}	3023
LSD	**	*	*	**	NS

NS = Not significant, * Significant at p=0.01, ** Significant at p=0.05

*Numbers followed by different letters in superscript are significantly different at P=0.05

DL= damaged leaves; DH= dead hearts; WE= white ears

plots receiving RDF. However, yield reductions have been recorded in organically manured plots by previous workers. For instance, Mader et al. (2002) reported a 20% crop yield reduction in organic systems although the pesticide inputs were reduced by 97%. Likewise, the cost benefit ratio for organically grown rice was 26% less in the first year, but it improved by 22% at the end of the fourth year (Surekha et al., 2010).

The present study revealed that organic manures have a positive impact on arthropod diversity in rice fields and is particularly beneficial to the restoration of natural enemies and improvement of the ecological environment. On the whole, the beneficial effects of natural control and reduced pesticide use should outweigh the yield losses associated with organic farming. However, increased farm mechanization with a consequent decline in the number of farm animals has created a scarcity of organic manures and increased costs. Recycling FYM within the farm could be a viable option. In any case, the cost benefit ratio should be worked out to decide if the ecological benefits accrued will compensate for the loss in yield. Future studies should, therefore, focus on the economics of the ecological benefits of increased biodiversity versus initial reduction in yields in organic systems.

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