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Humic Acid and Azadirachtin Derivatives for the Management of Crop Pests

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***Abstract*—**Organic cultivation of crops is gaining importance consumer awareness towards pesticide residue free foodstuffs is increasing globally. This is also because of high costs of synthetic fertilizers and pesticides, making the conventional farming non-remunerative. In India, organic manures (such as vermicompost) are an important input in organic agriculture. Though vermicompost obtained through earthworm and microbe-mediated processes is known to comprise most of the crop nutrients, but they are in small amounts thus necessitating enrichment of nutrients so that crop nourishment is complete. Another characteristic of organic manures is that the pest infestations are kept under check due to induced resistance put up by the crop plants. In the present investigation, deoiled neem cake containing azadirachtin, copper ore tailings (COT), a source of micro-nutrients and microbial consortia were added for enrichment of vermicompost. Neem cake is a by-product obtained during the process of oil extraction from neem plant seeds. Three enriched vermicompost blends were prepared using vermicompost (at 70, 65 and 60%), deoiled neem cake (25, 30 and 35%), microbial consortia and COTwastes (5%). Enriched vermicompost was thoroughly mixed, moistened (25+5%), packed and incubated for 15 days at room temperature. In the crop response studies, the field trials on chili (*Capsicum annum* var. longum) and soybean, (*Glycine max* cv JS 335) were conducted during *Kharif* 2015 at the Main Agricultural Research Station, UAS, Dharwad-Karnataka, India. The vermicompost blend enriched with neem cake (known to possess higher amounts of nutrients) and vermicompost were applied to the crops and at two dosages and at two intervals of crop cycle (at sowing and 30 days after sowing) as per the treatment plan along with 50% recommended dose of fertilizer (RDF). 10 plants selected randomly in each plot were studied for pest density and plant damage. At maturity, crops were harvested, and the yields were recorded as per the treatments, and the data were analyzed using appropriate statistical tools and procedures. In the crops, chili and soybean, crop nourishment with neem enriched vermicompost reduced insect density and plant damage significantly compared to other treatments. These treatments registered as much yield (16.7 to 19.9 q/ha) as that realized in conventional chemical control (18.2 q/ha) in soybean, while 72 to 77 q/ha of green chili was harvested in the same treatments, being comparable to the chemical control (74 q/ha). The yield superiority of the treatments was of the order neem enriched vermicompost>conventional chemical control>neem cake>vermicompost>untreated control. The significant features of the result are that it reduces use of inorganic manures by 50% and synthetic chemical insecticides by 100%.

***Keywords*—**Humic acid, azadirachtin, vermicompost, insect-pest.

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I. Introduction

ORGANIC wastes such as agricultural, animal, agro-industrial, aquatic, forest litter and a portion of municipal and city solid wastes (MSW) are produced each year in India in significant quantities [1], [2]. Among this biomass, while agricultural and animal wastes together account for 2100 plus MT, the quantity of agro-industrial and other wastes produced is very huge. Unscientific and environmentally unsafe methods of waste disposal are followed by the farmers, e.g., burning of crop residues such as trash, stalks of crops, etc., leading to air pollution affecting human health. Hence, there is a good scope to bio-recycle this waste into resources viz., organic composts. Bio-recycling of organic wastes assumes greater significance in the present context of climate change impact on crop yields and losses, as this has got the great potential for income generation.

Indiscriminate use of chemical fertilizers and pesticides in crop production has led to problems such as loss of soil fertility, insect resistance to pesticides, accumulation of pesticide residues in food grains and vegetable and fruits, etc., the latter having an adverse effect on human health. At the same time, there is also a growing demand for organically grown food worldwide and the government of India formulated National Programme on Organic Production (NPOP) and National Standards for Organic Production (NSOP) during the year 2000 to give a fillip to organic farming [3]. This is obviously due to the importance of such eco-friendly farming systems that have a significant influence on soil health, ecology and environment. As per a recent report of International Federation of Organic Agriculture Movements (IFOAM) the total organically managed land area is increasing, and organic cultivation is practiced in approximately 130 countries of the world [4]. With the sizable area under naturally organic or default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world organic market.

Among the agents having potential in organic matter re-cycling, the role played by earthworms and microbes is very significant [5], [6]. The worm-microbe mediated organic matter biodegradation leads to unlocking of various easily absorbable plant nutrients in the end product, vermicomposting.

These organic composts are known to comprise most of the crop nutrients, but the quantities, especially nitrogen are in small amounts [7] thus necessitating nutrient enrichment so that crop nourishment is improved. Organic crop nourishment is also known to induce resistance properties in crop plants.

Literature scan indicates reduced activity of insect-pests and crop damage when plants are nourished with vermicompost [8]-[10]. However, reports on the influence of neem enriched vermicompost v/s crop pests are very few [8]-[11]. With this in focus neem, copper ore tailing waste (COT) by a product of gold mines and microbial consortia were added for enrichment, and the studies were carried out with the objectives as given below:

1. To assess nutrient status of enriched vermicompost fortified with neem cake, COT waste, and microbial consortia
2. To study the effect of crop nourishment with enriched vermicompost on the pest debilitations and yield.

II. Materials and Methods

Studies on vermicompost enrichment and crop responses were conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka-India) during the period 2013 to 2015.

In the laboratory experiment on the enrichment of vermicompost, three blends were prepared using vermicompost at 70, 65, 60 percent and deoiled neem cake at 25, 30 and 35% and 5% COT and microbial consortia for overall quality enrichment. The microbial consortia consisting of *Azotobacter*, *Azospirillum,* P (Phosphate and Potash) solubilizers and *Trichoderma* was added to blends @ two gram per 100 grams of the blend.

Vermicompost blends were later thoroughly mixed, moistened (25±5%), packed and incubated for 15 days at room temperature. Nutrient estimation in vermicompost blends was done using standard procedures [12], [13]. Microbial enumeration of blends was done by following serial dilution plate count technique [14], [15].

In the crop response studies made on chilli and soybean and laid out in a randomized block design and replications, vermicompost blends enriched with neem cake and only vermicompost were applied to the crops at two dosages and at two intervals of crop stages (at sowing or transplanting and 30 days after) as per the treatment plan along with 50% of RDF.

A standard chemical check treatment with 100% RDF and insecticidal plant protection and an untreated check were maintained in the experimentation for comparison of results. In treatments T_1 to T_{10}, two sprays each of neem and *Verticillumlecani* bio-spray were given.

During experimentation, ten plants selected randomly in each experimental plot were observed for pest density and plant damage. Leaf curl caused by sucking insect pests [16] and fruit damage caused by fruit borer insect-pests in chili, defoliator pest density and pod damage caused by pod feeding insects in soybean were observed for assessing the effect of neem enriched vermicompost on pest activity leading to crop damage.

During harvesting yields of both the crops as per the experimental plan were recorded and the data on various parameters were analyzed by following suitable statistical procedures (as shown in Table I).

III. Results and Discussion

Results obtained pertaining to nutrient estimations (as shown in Table II) indicated that nitrogen, P_20_5 and K_2O (major nutrient elements), Zinc, Copper, Iron and Magnesium (micronutrient elements) in neem enriched vermicompost were higher as composed to vermicompost without enrichment. A good amount of major nutrients was added due to enrichment with nitrogen-rich neem cake and activity of microbial during the period of incubation for three weeks. The microflora (CFU/g) viz, bacteria, fungi, and actinomycetes observed in neem enriched vermicompost were higher as compared to vermicompost (Table III).

Enrichment with organic materials of plant origin, mine wastes such as COT and microbial consortia is known to enhance nutrient levels to the tune of 10 to 50%. [17]-[19]. This is possibly due to higher microbial enzyme activities such as urease, dehydrogenase, phosphatase in enriched vermicompost. Use of microbial consortia in cow manure based substrates is reported to add nutrients to vermicompost [20]. Neem cake application for the enrichment of materials is reported to have an influence on the establishment of microflora [17], [21], [22].

The results with respect to crop responses *viz*, pest debilitations, crop damage and yields in two crops experimented for assessing the effect of neem enriched vermicompost were significant. The significantly lower density of defoliator insects on soybean crop at 1.5 to 1.7 larvae/meter row length was recorded in treatments receiving neem enriched vermicompost as crop nourishment which was comparable to the population density observed in chemical check (1.1 larvae/m, row length) (Fig. 2).

Similarly, in chilli crop where leaf curl and fruit damage due to a group of insect-pests, i.e., sucking insect-pests (aphids, thrips, mites, etc.) and fruit borer (*Helicoverpaarmigera*), application of neem enriched vermicompost resulted in reduced leaf curl (0.5 to 1.3 LCI in 0 to 4 scale) V/s 1.1 LCI observed in the chemical check. The fruit damage % seen in these treatments was significantly lower (4.8% to 6.7%)and was comparable to the standard chemical check (4.5%) (as shown in Fig. 1).

Effective pest management in these treatments, lead to improved crop yields too both in soybean and chili. The yields of both chili and soybean were significant, and the crop nourished with neem enriched vermicompost registered superior yields, which were comparable to the standard check (as shown in Figs. 3 and 4).

Organic nourishment is known to induce resistance in plants by changing the chemistry of the host plant affecting development and survival of the insects [21], effect changes in the phenological-characters such as leaf succulence, trichome density leaf area, etc. and biochemical parameters i.e. accumulation of metabolites in the plant tissues [7], [9], [22], [23]. Neem cake is known to comprise a group of limonoids is a good insect antifeedant [6], [8], [15], [24], [25] which is known to negatively influence the insect feeding, besides its effects on growth and development of the insect. Soil application of neem results in translocation of the substances

into the plant system of tissues and giving durable effects on pest activity as compared to the foliar application.

TABLE I
TREATMENT DETAILS

Sl. No.	Treatment
T_1	Neem enriched vermicompost (NVC) @ 2.5 T/ha with 50% RDF and two sprays Neem and *L. lecani*
T_2	NVC @ 4.0 T/ha with 50% RDF and two sprays Neem and *V. lecani*
T_3	Split application of 2.5 T/haNVC at sowing and 30 DAS
T_4	Split application of 4.0 T/ha NVC at sowing and 30 DAS
T_5	Vermicompost @ 2.5 T/ha at sowing and 30 DAS
T_6	Vermicompost @ 4.0 T/ha at sowing and 30 DAS
T_7	Split application of 2.5T/ha vermicompost at sowing and 30 DAS
T_8	Split application of 4.0T/ha vermicompost at sowing and 30 DAS
T_9	Neem cake @ 500 kg/ha at sowing and 30 DAS
T_{10}	Split application of 500 kg Neem cake at sowing and 30 DAS
T_{11}	Standard check (University RDF+Farm Yard Manure and recommended chemicals for plant protection)
T_{12}	Untreated check

TABLE II
MAJOR AND MICRO-NUTRIENT ESTIMATIONS

Sl. No	Material	N (%)	P (%)	K (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mg (ppm)
1	Neem enriched vermicompost	1.88	0.87	0.83	133.9	47.2	142.8	109.3
2	Vermicompost	1.29	0.67	0.54	121.1	37.7	132.1	105.8

TABLE III
MICROFLORA OBSERVED ASCFU/G

Sl. No.	Material	Bacteria	Fungi	Actinomycetes
1	Neem enriched vermicompost	$10.1x10^8$	$12.1x10^4$	$4.3x10^8$
2	Vermicompost	$8.4x10^7$	$9.5x10^3$	$2.2x10^4$

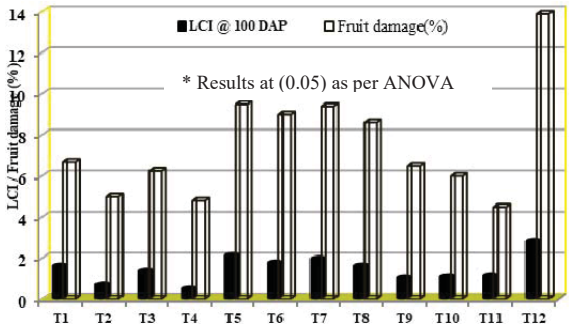

Fig. 1 Leaf Curl Index and Fruit damage as influenced by enriched vermicompost application in chili

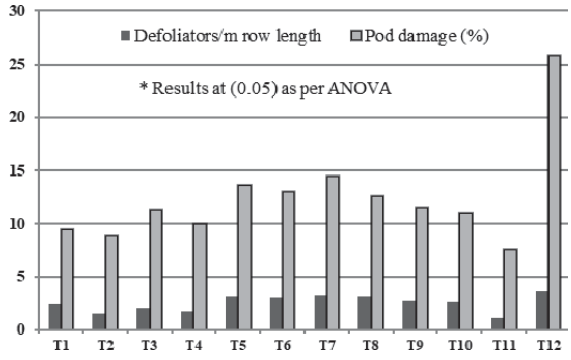

Fig. 2 Soybean defoliators and Pod damage as influenced by the application of enriched vermicompost (*Kharif*-2015)

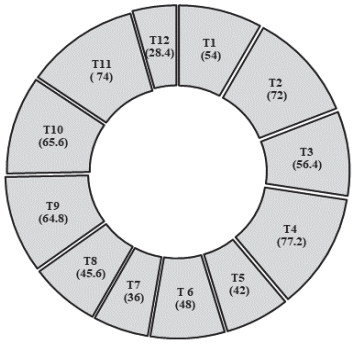

Fig. 3 Green chili yield (q/ha) as influenced by application of enriched vermicompost *Results at (0.05) as per ANOVA

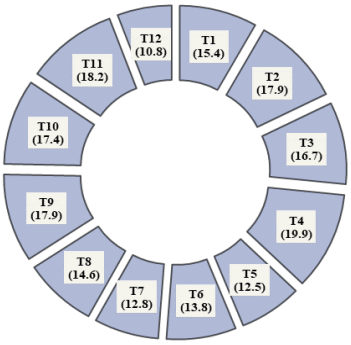

Fig. 4 Soybean yield (q/ha) as influenced by application of enriched vermicompost *Results at (0.05) as per ANOVA

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