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Potency of combination of liquid biofertilizer with biopesticide on productivity of Brinjal and infestation of *Leucinodes orbonalis* (Pyraustidae: Lepidoptera)

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ABSTRACT

Lucinoides orbonalis is a serious pest of brinjal which caused 70-80% economic loss productivity in eastern Uttar Pradesh . The foliar application of mixture of combination of vermiwash obtained from animal dung and municipal solid wastes (MSW) with biopesticides (neem leaf, bark and oil) have significant increase in early flowering, growth, and productivity as well as reduction in pest infestation of brinjal. The combination of vermiwash of buffalo dung and MSW (2:1 ratio) with neem oil is a best combination for better growth, early flowing and productivity as well as pest infestation reduction. The use of vermiwash with biopesticides is a alternative of chemical fertilizers and synthetic pesticides because it is eco-friendly and boon for farmers.

Key words: *Animal and municipal solid wastes (MSW), Vermiwash, bio-pesticide, Leucinodes orbonalis , Brinjal productivity, Pest Infestation.*

INTRODUCTION

Brinjal (*Solanum melogenum*) is one of the important Solanaceous vegetable cultivated in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and the Philippines[18]. The crop is grown during the monsoon period where the supplement irrigation is available. Eggplant is well adapted to high rainfall, high temperatures, and is among the few vegetables capable of high yields in hot-wet environments[34]. Brinjal fruit contains nutrients such as dietary fiber, folate, ascorbic acid, vitamin K, niacin, vitamin B_6, pantothenic acid, potassium, iron, magnesium, manganese and phosphorus. It is low in calories and fats, contains mostly water, some protein, fiber and carbohydrates. It is a good source of minerals and vitamins and is rich in total water soluble sugars, free reducing sugars, amide proteins among other nutrients[24].

Leucinodes orbonalis (Pyraustidae: Lepidoptera) monophagous insect pest and commonly known as shoot /fruit borer and most serious pest of brinjal and causes yield loss up to 60-70%. The infestation starts during early stage of the crop and continues throughout the fruiting stage. Initially the larvae attacks the shoots result in drooping of shoots and dead heart. Later stages, the larvae starts to feed on flower buds and fruits but it prefer more on fruits, the infestation during fruit set causes shedding of buds. Larvae bore the fruits and holes are sealed -with excreta and make them unfit for consumption[2,25].

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The adult moths are white in colour with brownish red marking on the fore wing and it lays an average of 250 eggs singly on the tender shoots, flowers and developing buds. Larvae are pinkish in colour and fully developed with prominent head capsule with sparse hairs on their body. Pest is active throughout the year but more during monsoon. The pupation takes place in the plant debris with brownish cocoon. The egg, larval and pupal period is 3-5, 15 and 7 days respectively and it varies with season[2,25]. Upon hatching, the larva starts boring near the growing point or into the flower buds or fruits. During the early vegetative phase of the crop growth, it feeds on the tender shoots. Soon after boring into the shoots and fruits, the larva seals the entry hole with excreta. The larva tunnels inside the shoot and feeds on the inner contents. It also fills the feeding tunnels with excreta. This result in wilting of young shoots .In addition, it produces new shoots, delaying crop maturity. During the early reproductive phase, the larva occasionally may feed on flower buds and flowers. However, it prefers to feed on the fruit rather than other plant parts during the fruiting stage of the crop. Damaged fruit exhibits boreholes on the surface, which often are sealed with excreta. The larva feeding inside the fruit creates tunnels filled with frass and fecalpellets. Hence, the fruit becomes unfit for marketing and consumption[3,4,19,54,59] . The use of synthetic pesticides against insect pests increased the cost of production at farmer level and increase the environmental and health hazards at consumer level. Chemical fertilizers and pesticide have been altered not only the soil quality but also changed the physico-chemical nature as well as contaminated the fruits[26,32]. The pesticides of chemical origin have also affect the diversity of non-target organism. The use of biofertilizers with biopesticides is economic for farmers and non- hazardous to human and animal health as well as environment[60]. Neem is the most versatile, multifarious trees of tropics with immense potential. It possesses maximum useful non-wood products (leaves, bark, flowers, fruits, seed, gum, oil and neem cake) than any other tree species[17,29]. Nimbidin has anti-inflammatory, antiarthritic, antipyretic, hypoglycaemic, antigastric ulcer, spermicidal, antifungal, antibacterial, diuretic whereas, nimbin has spermicidal, nimbolide- ntibacterial, antifungal, antimalarial properties.

Animal dung, kitchen and agro-wastes as well as municipal solid wastes (MSW) creates serious problems for society, caused environmental hazards and various ill effects on human life and their domestic animals, if their proper management and disposal practices are not available[16,20,21,49,68]. The biological wastes as well as municipal solid wastes (MSW) generated in metropolitan cities are major problem for the society in the absence of proper technology of their managements[65]. Vermicomposting with the help of earthworm *Eisenia fetida* is an appropriate technology for safe, hygienic and cost effective disposal of biological wastes and conversion in to good quality biofertilizers[23]. The epigeic earthworm species *Eisenia fetida* is a suitable earthworm species for vermicomposting which have short life cycle, small size and high rate of conversion of organic wastes as well as reproduction[20,22,52]. The vermiwash is the liquid extract of vermicompost and have various nutrient, enzymes, vitamins and plant growth hormones[75]. The vermiwash of municipal solid wastes have also high amounts of organic matter, plant nutrients and soluble salts which increase the soil nutrientand moisture content[13,43]. Vermiwash with biopesticide is the better option for the growth, productivity as well as control of *Helicoverpa* population in gram plant. Combination of buffalo dung + MSW with neem oil/garlic extract is very effective combination for growth and productivity of gram plant.

Aim of the present study is to find out the potency of combination of liquid biofertilizer with biopesticide on productivity of Brinjal and infestation of *Leucinodes orbonalis* (Pyraustidae: Lepidoptera).

MATERIALS AND METHODS

Collection of MSW and experiment set up for vermicomposting

Municipal solid wastes (MSW) and buffalo dung were collected from the local municipality and form house of Gorakhpur city. Vermibeds were prepared from municipal solid wastes with animal dung in different ratio and exposed to the sunlight for 5 to 10 days to remove the various harmful organisms and

noxious gases. After pretreatment, adult earthworms *Eisenia fetida* were inoculated in each vermibed for vermicomposting. The vermibed covered with jute packet and moistened daily up to 40-50 days for maintaining the moisture (50% to 60% RH). After one week interval vermibed were turned manually. The tea like granules, brown color have been appeared on the upper surface of each vermibed after 60 days; fresh vermicompost collected for extraction of vermiwash[48].

Extraction of vermiwash

Vermiwash were extracted from prepared vermicompost by the help of vermiwash collecting device. The apparatus is made from plastic drum having capacity of five liter and a tap at the bottom. The drum is filled with broken bricks, about 3 cm thickened which is followed by sand layer of 2-3 cm thickness lastly filled by prepared vermicompost with earthworms, simultaneously one liter fresh water was added in to the drum and after 10 hours a container kept below the tap for the collection of vermiwash[48].

Extraction of neem (*Azadirachta indica* A. Juss.)

Neem leaves, bark and fruit were collected from local area of Gorakhpur U.P. India.Neem leaves and bark were crushed in water. After preparation of aqueous extract of leaf, bark, and oil were mixed with vermiwash in ratio of 1:20. The mixtures of vermiwash with bio- pesticide were diluted with ten times water for treatment(w/v). Prepared vermiwash with biopesticides sprayed in brinjal crop at interval of 10 days after plantation.

Measure the growth, productivity of Brinjal and infestation of *Leucinodes orbonalis*

The 40 days old seedlings of Brinjal (*Solanum melogenum*) – Pusa Krantiwere planted in agricultural field. Randomly selected six spots, each square meter area were used for sowing the crops. For measurement of growth (cm.) randomly selectedplant from each spot and use Auxanometer at the interval of 10 days after 30 days of plantation. The productivity was measured as kg/m^2 of brinjal crop. The different combinations of vermiwash with neem biopesticides was sprayed over the crops after each 10 days interval for the measurement of growth whereas, at the time of starting of flowering after each 10 days interval the different combinations of vermiwash with biopesticides was sprayed over the crops and control have no treatment.

Statistical Analysis

All experiments were replicated six times. Significant variance ($p<0.05$) determined by three way analysis of variance (ANOVA) was applied in between different treatment and different parameters[70].

RESULTS

The foliar application of aqueous mixture of combination of vemiwash with neem oil, leaf and bark have increased the brinjal plant growth early flowering ,increased productivity as well as caused a significant reduction in percent pod infestation of pest (Table 1- 4). The binary combination of vermiwash with neem oil, leaf and bark results significant growth of brinjal plant (Table 1-4).The highest growth of brinjal was (30.01±0.86cm) observed after spray of vermiwash of buffalo dung and municipal solid wastes (MSW) with neem oil in comparison to all other treatments.The flowering period of brinjal in control was (74.07±0.79)days. Early flowering was observed in all the treatment of vermiwash with neem plant parts. The earliest flowering of brinjal was (60.01±0.56) days after foliar spray of vermiwash of buffalo dung and MSW (2:1) with neem oil followed by buffalo dung and MSW (2:1) with neem bark (62.26±0.10) days and neem leaf (63.14±0.59) days.

The significant increase in productivity of brinjal was observed in all the combination of vermiwash obtained from different combination of animal dung and MSW with neem plant parts. The significant maximum productivity of brinjal (7.16±0.59) was obtained after foliar application of combination of vermiwash obtained from buffalo dung and MSW with neem oil (Table 1-4). The significant ($P< 0.05$) was found when three way analysis of variance(ANOVA) applied in between different treatment and different parameters (Table-5).

Table1- Effect of different combinations of vermiwash of different animal dung with municipal solid wastes on growth, flowering, productivity of brinjal plant and per cent pod pest infestation of *Leucinodes orbonalis*

Treatment (w/v)	Combination Ratio	Growth (cm) Spray periods after planting (Days) 30	40	50	Flowering (days)	Productivity (kg/m²)	% Pod pest infestation Spray periods after flowering (days) 80	90	100
Control	–	7.59± 0.57	13.15± 0.71	16.37± 0.59	74.07 ± 0.79	1.98± 0.36	50.05± 0.64	65.19± 0.58	80.88± 0.60
MSW	_	11.30± 0.71	18.45± 0.69	21.63± 0.56	72.39 ± 0.61	2.18±0.36	40.21± 0.60	36.30± 0.46	31.45± 0.77
Goat Dung	–	#13.18± 0.72	16.39± 0.54	20.09±0.73	65.88 ± 0.77	3.86± 0.40	#28.09± 0.84	23.53± 0.58	19.32± 0.70
Goat Dung +MSW	1:1	*14.97± 0.52	17.39± 0.69	21.06± 0.37	65.26 ± 0.54	4.17± 0.58	*27.11± 0.64	22.11± 0.58	17.71± 0.52
	1:2	15.3± 0.61	18.51± 0.57	21.85± 0.43	64.53 ± 0.77	5.00± 0.81	26.02± 0.58	24.01±0.83	18.91± 0.46
	2:1	15.19± 0.55	19.46± 0.72	23.40± 0.64	64.04 ± 0.56	4.26± 0.53	24.91± 0.59	25.07± 0.30	16.99± 0.63
Horse Dung	–-	#14.87± 0.52	17.33± 0.56	23.57± 0.48	68.95 ±0.71	4.06± 0.54	#25.77± 0.51	23.19± 0.52	16.61± 0.89
Horse Dung +MSW	1:1	*15.73± 0.67	18.55± 0.59	24.25± 0.49	68.10 ± 0.87	4.29± 0.57	*27.51± 0.79	22.58± 0.46	17.41± 0.48
	1:2	16.37± 0.51	21.06± 0.64	25.66± 0.54	67.07 ± 0.76	5.17± 0.61	26.26± 0.53	24.42±0.51	19.71± 0.67
	2:1	16.84± 0.64	20.35± 0.49	25.58± 0.56	66.38 ± 0.51	5.39± 0.47	27.79± 0.52	21.59±0.71	18.72± 0.59
Buffalo Dung	–-	#15.23± 0.61	18.33± 0.65	23.54± 0.54	71.04 ± 0.75	3.98± 0.60	#22.61± 0.73	20.02± 0.56	18.07± 0.68
Buffalo Dung+MSW	1:1	*17.34± 0.55	20.45± 0.53	24.60± 0.66	67.51 ± 0.51	5.42± 0.63	*21.37± 0.53	18.37± 0.57	17.01± 0.55
	1:2	17.80± 0.66	20.60± 0.61	26.41± 0.67	66.58 ± 0.78	5.72± 0.69	23.03± 0.55	19.01± 0.48	16.02± 0.74
	2:1	**18.26± 0.59**	**21.85± 0.57**	**28.89± 0.64**	**63.91± 0.84**	**5.93± 0.67**	**21.09±0.55**	**20.10±0.90**	**15.69±0.43**
Cow Dung	–-	#15.04± 0.57	18.05±0.58	23.32± 0.55	68.84 ± 0.79	$2.98±0.56	#23.91± 0.43	20.79± 0.67	19.87± 0.75
Cow Dung+MSW	1:1	*15.82± 0.56	18.79± 0.58	23.84± 0.55	67.69 ± 0.71	3.75± 0.64	*24.65± 0.50	21.89±0.89	20.19± 0.85
	1:2	16.02± 0.65	18.98± 0.88	25.46± 0.66	68.70 ± 0.70	4.79± 0.51	25.05±0.61	22.07±0.73	18.51±0.64
	2:1	16.80± 0.63	19.46± 0.58	26.66± 0.54	67.46 ± 0.82	5.27± 0.55	26.76± 0.74	22.93± 0.45	16.49± 0.47

Each value is the mean ± SE of six replicates.
3 way ANOVA: Significant (P< 0.05) * within column, # within row.

Table2- Effect of different combinations of vermiwash of different animal dung with municipal solid waste and aqueous extract of neem leaf on growth, flowering and productivity of brinjal plant and per cent pod pest infestation of *Leucinodes orbonalis*

Treatment (w/v)	Combination Ratio	Growth (cm) Spray periods after planting (Days) 30	40	50	Flowering (days)	Productivity (kg/m²)	% Pod pest infestation Spray periods after flowering (days) 80	90	100
Control	–	7.59± 0.57	13.15± 0.71	16.37± 0.59	74.07 ± 0.79	1.98± 0.36	50.05± 0.64	65.19± 0.58	80.88± 0.60
MSW+NL	_	13.29± 0.83	15.46± 0.73	22.78± 0.28	70.05 ± 0.49	2.43±0.26	30.66± 0.62	25.17± 0.57	18.98± 0.50
Goat Dung+ NL	–	#13.90± 0.56	16.66± 0.58	20.84±0.65	65.37 ± 0.48	3.98± 0.73	#22.49± 0.57	16.77± 0.58	14.81± 0.63
Goat Dung +MSW+ NL	1:1	*15.27± 0.55	17.98± 0.59	21.89± 0.58	64.24 ± 0.66	4.73± 0.49	*20.83± 0.64	15.20± 0.55	13.79± 0.57
	1:2	15.85± 0.61	18.97± 0.62	22.96± 0.60	63.76 ± 0.63	5.15± 0.81	22.88± 0.58	15.07±0.45	12.48± 0.55
	2:1	16.28± 0.52	19.92± 0.53	24.28± 0.53	68.21 ± 0.53	5.54± 0.74	21.75± 0.59	14.92± 0.62	11.68± 0.53
Horse Dung + NL	–-	#15.26± 0.49	18.86± 0.54	25.38± 0.55	66.76 ±0.58	4.26± 0.60	#21.52± 0.77	15.74± 0.59	14.20± 0.52
Horse Dung +MSW+ NL	1:1	*16.39± 0.57	20.26± 0.50	25.96± 0.57	66.17 ± 0.57	4.65± 0.74	*22.36± 0.79	14.78± 0.58	12.46± 0.58
	1:2	16.70± 0.55	20.68± 0.60	26.36± 0.59	69.25 ± 0.56	5.48± 0.64	21.41± 0.53	13.56±0.64	10.15± 0.54
	2:1	17.36± 0.54	21.54± 0.62	26.88± 0.58	67.61 ± 0.75	5.64± 0.77	22.04± 0.62	12.58±0.57	9.20± 0.51
Buffalo Dung +NL	–-	#15.64± 0.59	18.43± 0.61	24.26± 0.56	66.32 ± 0.62	4.19± 0.81	#22.56± 0.73	16.49± 0.56	13.18± 0.59
Buffalo Dung +MSW+NL	1:1	*17.75± 0.58	20.68± 0.63	26.32± 0.59	64.24 ± 0.60	6.22± 0.66	*21.12± 0.84	14.20± 0.61	12.26± 0.58
	1:2	18.04± 0.54	21.56± 0.56	27.86± 0.54	68.76 ± 0.48	6.11± 0.80	21.86± 0.57	13.97± 0.60	9.82± 0.69
	2:1	**18.36± 0.60**	**21.96± 0.57**	**29.12± 0.55**	**63.14± 0.59**	**6.37± 0.92**	**20.32±0.59**	**11.16±0.56**	**8.18±0.56**
Cow Dung+ NL	–-	#15.66± 0.61	18.39±0.55	23.87± 0.75	69.38 ± 0.61	3.53±0.62	#21.08± 0.63	14.17± 0.51	12.93± 0.64
Cow Dung+ MSW+ NL	1:1	*17.22± 0.53	20.37± 0.52	25.66± 0.52	66.27 ± 0.54	3.65± 0.69	*21.17± 0.72	13.13±0.52	11.38± 0.53
	1:2	17.88± 0.62	21.28± 0.64	26.94± 0.68	66.01 ± 0.20	4.57± 0.79	21.19±0.83	12.14±0.57	8.94±0.65
	2:1	18.08± 0.57	21.75± 0.57	27.56± 0.63	66.09 ± 0.63	5.73± 0.69	21.39± 0.64	11.12± 0.53	7.90± 0.68

Each value is the mean ± SE of six replicates.
3 way ANOVA: Significant (P< 0.05) * within column, # within row.
NL-Neem Leaf .

Table 3-Effect of different combinations of Vermiwash of different animal dung and municipal solid wastes with neem oil on growth, flowering, productivity of brinjal & Per cent pod pest infestation of *Leucinodes orbonalis*

Treatment (w/v)	Combination Ratio	Growth (cm) Spray periods after planting (Days) 30	40	50	Flowering (days)	Productivity (kg/m^2)	% Pod pest infestation Spray periods after flowering (days) 80	90	100
Control	--	7.59± 0.57	13.15± 0.71	16.37± 0.59	74.07± 0.79	1.98± 0.36	50.05± 0.64	65.19± 0.58	80.88± 0.58
MSW+NO	--	12.76± 0.83	15.44± 0.73	22.44± 0.28	69.13± 0.49	2.69± 0.26	27.39± 0.62	23.24± 0.57	16.21± 0.50
Goat Dung+NO	--	# 14.50± 0.60	16.68± 0.55	21.35± 0.67	65.54± 0.61	4.19± 0.63	#20.16± 0.55	11.45± 0.62	10.88± 0.69
Goat Dung +MSW+NO	1:1	*15.79± 0.67	18.29± 0.64	22.47± 0.52	65.10± 0.63	4.56± 0.61	*20.05±0.56	10.63± 0.70	10.05± 0.57
	1:2	16.48± 0.59	19.33± 0.60	23.49± 0.68	64.12± 0.60	5.71± 0.47	21.33±0.29	10.95± 0.72	6.93± 0.84
	2:1	17.68± 0.74	20.45± 0.56	24.78± 0.50	63.67± 0.45	6.17± 0.52	20.09± 0.54	7.43± 0.59	5.75± 0.60
Horse Dung+NO	--	#15.45± 0.49	19.23± 0.51	25.63± 0.56	68.30± 0.57	4.39± 0.59	#20.35± 0.60	10.82± 0.56	7.65± 0.61
HorseDung+MSW+NO	1:1	*16.47± 0.61	20.48± 0.54	26.29± 0.63	68.01± 0.53	4.95± 0.56	*21.22± 0.31	9.48±0.49	6.02± 0.44
	1:2	17.28± 0.50	21.33± 0.59	27.14± 0.61	66.18± 0.82	5.69± 0.58	20.51± 0.62	9.22± 0.67	5.29± 0.65
	2:1	17.86± 0.75	21.96± 0.76	27.70± 0.67	65.66± 0.85	6.23± 0.64	20.22± 0.64'	7.21± 0.66	4.76± 0.56
Buffalo+NO	--	#15.97± 0.67	18.58± 0.62	24.80± 0.63	68.86± 0.62	#4.49± 0.60	22.28± 0.65	8.22± 0.60	3.11±0.68
Dung+MSW+NO	1:1	* 18.23± 0.58	20.68± 0.66	26.63± 0.69	67.29±0.65	6.08± 0.62	*20.11± 0.60	6.14± 0.59	2.58± 0.54
	1:2	18.79± 0.62	22.45± 0.59	28.32± 0.62	65.66± 0.58	6.48± 0.61	21.48± 0.66	4.09± 0.58	1.12± 0.41
	2:1	**19.57± 0.72**	**23.28± 0.58**	**29.91± 0.70**	**60.01± 0.56**	**7.16± 0.59**	**20.21± 0.61**	**3.04± 0.61**	**nil**
CowDung+NO	--	#16.12± 0.59	18.75± 0.60	24.25± 0.68	68.08± 0.31	3.60± 0.65	#21.49± 0.70	9.89± 0.76	4.01± 0.77
Cow Dung+MSW+NO	1:1	*17.77± 0.48	20.65± 0.46	25.97±0.73	68.67± 0.50	4.19± 0.56	*20.10± 0.56	9.16±0.60	5.03± 0.56
	1:2	18.42± 0.80	21.76± 0.56	21.76± 0.62	66.55± 0.66	4.98± 0.57	20.58± 0.63	7.14±0.48	6.01± 0.53
	2:1	18.89± 0.57	22.50± 0.66	22.50± 0.76	65.26± 0.61	6.03± 0.60	21.27±0.62	5.23± 0.55	5.33± 0.58

Each value is the mean ± SE of six replicate.
3 way ANOVA: Significant ($P< 0.05$) * within column, # within row.
NO- neem oil

Table 4- Effect of different combinations of vermiwash of different animal dung with municipal solid waste and neem bark on growth, flowering, productivity of brinjal plant and per cent pod pest infestation of *Leucinodes orbonalis*

Treatment (w/v)	Combination Ratio	Growth (cm) Spray periods after planting (Days) 30	40	50	Flowering (days)	Productivity (kg/m^2)	% Pod pest infestation Spray periods after flowering (days) 80	90	100
Control	–	7.59± 0.57	13.15± 0.71	16.37± 0.59	74.07 ± 0.79	1.98± 0.36	50.05± 0.64	65.19± 0.58	80.88± 0.60
MSW + NB	_	12.85±0.83	14.95± 0.73	22.11± 0.28	70.25 ± 0.49	2.50±0.28	30.45± 0.62	26.06± 0.57	20.77± 0.50
Goat Dung + NB	–	#14.69± 0.17	17.39± 0.28	21.75±0.30	63.23 ± 0.97	4.27± 0.57	#19.13± 0.59	9.55± 0.55	7.78± 0.47
Goat Dung + MSW+ NB	1:1	*15.87± 0.82	18.61± 0.78	22.89± 0.86	62.77 ± 0.27	4.79± 0.52	*19.56± 0.51	7.42± 0.42	5.94± 0.37
	1:2	16.65± 0.38	19.79± 0.49	23.77± 0.86	61.79 ± 1.52	5.55± 0.80	20.71± 0.40	6.35±0.34	6.61± 0.28
	2:1	18.29± 0.23	20.91± 0.47	24.34± 0.96	60.88 ± 0.27	5.96± 0.53	19.53± 0.37	5.35± 0.27	4.44± 0.20
Horse Dung + NB	–-	# 5.88± 0.17	19.70± 0.28	25.79± 0.32	66.11 ±0.51	4.48± 0.62	#19.68± 0.64	9.12± 0.54	5.67± 0.48
Horse Dung +MSW+NB	1:1	*17.19± 0.29	21.32± 0.51	26.85± 0.87	65.89 ± 0.27	4.99± 0.54	*20.67± 0.54	6.71± 0.48	4.45± 0.38
	1:2	17.43± 0.26	21.61± 0.42	27.59± 0.94	63.42 ± 0.15	5.59± 0.78	21.54± 0.47	5.66±0.31	4.04± 0.32
	2:1	18.29± 0.33	22.57± 1.20	27.91± 0.95	63.05 ± 0.07	6.15± 0.74	22.04± 0.42	4.39±0.29	3.69± 0.24
Buffalo Dung + NB	–-	#16.39± 0.35	19.32± 0.26	25.29± 0.29	66.11 ± 0.48	4.60± 0.56	#20.19± 0.56	9.20± 0.49	4.97± 0.40
Buffalo Dung +MSW+NB	1:1	*18.49± 0.36	21.27± 0.54	26.88± 1.40	64.71 ± 0.19	6.45± 0.51	*19.51± 0.51	7.05± 0.46	3.69± 0.37
	1:2	19.37± 0.40	22.89± 0.42	28.58± 0.87	63.20 ± 0.17	6.59± 0.57	20.97± 0.42	5.48± 0.31	2.77± 0.26
	2:1	**19.85± 0.28**	**23.77± 0.57**	**30.01± 0.86**	**62.26± 0.10**	**6.96± 0.63**	**20.54±0.33**	**4.08±0.20**	**2.11±0.37**
Cow Dung + NB	–-	#16.64± 0.15	19.37±0.25	24.69± 0.29	65.61 ± 0.49	3.74±0.66	#20.49± 0.58	8.61± 0.46	6.69± 0.40
Cow Dung +MSW+NB	1:1	*18.39± 0.29	20.87± 0.45	26.33± 0.79	65.11 ± 0.17	4.07± 0.70	*20.57± 0.49	5.76±0.38	5.03± 0.35
	1:2	18.91± 0.26	22.39± 0.59	27.73± 0.80	64.17 ± 0.21	5.03± 0.76	19.78±0.39	4.23±0.30	4.05±0.34
	2:1	22.77± 0.34	28.44± 0.62	28.29± 0.89	62.82 ± 0.31	6.01± 0.64	20.81± 0.36	3.15± 0.25	4.89± 0.17

Each value is the mean ± SE of six replicates.
3 way ANOVA: Significant ($P< 0.05$) * within column, # within row.
NB-Neem Bark

Table 5. Summary of computation of analysis of variance (ANOVA) of the data of Table 1,2,3,4

Source of variation		Flowering				Productivity kg/m^2					Percentage of pod infested after 100 days			
Components	**D.F.**	**S.S.**	**Variance (σ^2)**	**F-value**	**P**	**D.F**	**S.S.**	**Variance (σ^2)**	**F-value**	**P**	**D.F.**	**S.S.**	**Variance (σ^2)**	**F-value**	**P**
Between 6 Treatment	5	696.82	139.36	126.99	0.05	5	219.46	43.89	8.01	0.05	5	18876.85	3775.37	26.87	0.05
Between 4 Animal	3	11.59	3.86	3.52	0.05	3	40.84	13.61	2.48	0.05	3	11620.3	3873.43	27.56	0.05
Between 4 Pesticide	3	30.97	10.32	9.41	0.05	3	109.74	36.58	6.67	0.05	3	1867.76	622.58	4.43	0.05
Residual variation	84	92.19	1.097			84	460.19	5.47			84	11803.56	140.51		
Total	95	831.57				95	830.24				95	67226.27			

DISCUSSION

It is evident from result that the foliar application of aqueous mixture of combination of vemiwash with neem oil, leaf and bark have increased the plant growth,early flowering, increased productivity of brinjal as well as caused a significant reduction in per cent pod infestation of pest, it may be due to the presence

of different plant growth hormones and micro-macro nutrients in vermiwash. Vermiwash of different wastes are rich source of enzymes,vitamins, plant growth hormones (such as IAA, gibberellins, cytokinins) and also provide nutrients (such asphosphorus, potassium, calcium etc.)[10,31,51,52,53]. Singh and Chauhan[68] observed that the use of vermiwash of animal dung with municipal solid wastes (MSW) and neem based biopesticides have significant per cent germination of seed, growth, early flowering, productivity and reduced the *Eariasvittella* pest infestation.

The hormones auxin promotes the plant growth and gibberellins stimulate the early flowering in long photo-period plant[39]. Vermiwash / vermicompost are enriched in certain metabolites and vitamins which are important for plant growth and productivity[8,9,40]. The soil manganese and zinc content decreased with increased application time possibly because highly organic soils have lower manganese content. The organic material in the soil continuously increased with increased vermiwash[41,74]. Muscolo *et al*[47]., also found an auxin-like effect of earthworm worked to increase humic substances for cell growth and nitrogen metabolism in *Daucuscarota*. The potential effect of vermiwash was observed on okra[7,10].

The aqueous extract obtained from neempart and garlic caused a significant reduction in pod damage per cent and promotes the growth, early flowering and productivity of gram plant[12]. Wondafrash *et al*[73]., was also observed that the water extract obtained from neem leaf extract caused significant decrease in feeding and survival behavior of insect pest. The active component azadirachtin reduced the feeding behavior of larvae of various lepidopterous insects. Oligophagous species were more sensitive than polyphagous ones[63]. The volatiles of neem seed kernel prevented from contact and repelled the moths *H. armigera*[61]. Heyde *et al*[35]., reported that the spraying of 1- 50% emulsion of neem oil significantly reduced the food intake of homopterous insects.

The binary combination of vermiwash with neem oil , leaf and bark results significant growth of brinjal plant and highest growth of brinjal was observed after spray of vermiwash of buffalo dung and municipal solid (MSW) with neem oil with respect to all other treatments.Vermiwash of different animal and agro – waste have a significant amount of nitrogen, phosphorus, Ca, k, vitamins, enzymes, plant growth regulators, etc[37,48,49,53,71] and plant pesticide viz neem oil, aqueous extract of garlic bulb and leaf extract of custard apple have a toxic effect against aphid infestation[38,55,56].

Hossain and Poehling[36] reported that neem- based insecticide was effective against different immature life stages of Asian Leaf miner Liriomyza *sativae (Diptera:*Agromyzidae) on tomato.

The application of different neem products was effective against various rice, wheat, pulse and vegetable pest[45,58]. Mordue (Luntz)* and Nisbet[45]reported that the Azadirachtin from neem effects insects in a variety of different ways: as an antifeedent, insect growth regulator and sterilant. The antifeedant effects observed in these species are highly correlated with the sensory response of chemoreceptors on the insect mouthparts[44]. Feeding behavior depend upon both neural input from the insects chemical senses and central nervous integration. Azadirachtin stimulates specific ‘deterrent’ cells in chemoreceptors and also blocks the firing of ‘sugar’ receptor cells, which normally stimulate feeding[45,67]. This results in starvation and death of these species by feeding deterrency alone. In most other species of phytophagous insect however crop protection results from a combination of antifeedancy and physiological effects resulting from ingestion of azadirachtin. These physiological effects include ‘secondary’antifeedancy whereby feeding is reduced post-ingestively. These “secondary” antifeedant effects include ‘a reduction in food consumption and digestive efficiency subsequent and as a consequence of, ingestion, application or injection of the antifeedant[63]. The neem leaves contain numerous chemical with insecticidal property[1,66]. Neem triterpenoids showed growth regulating effects towards many species of insect[1,5,64].

The flowering period of brinjal in control was (74.07) days. Early flowering was observed in all the treatment of vermiwash with neem plant parts. The earliest flowering of brinjal was (60.01±0.56) days after foliar spray of vermiwash of buffalo dung and MSW (2:1) with neem oil followed by buffalo dung and MSW (2:1) with neem leaf and bark.The significant reduction in flowering period of mustard in all combination of vermiwash of different animal and agro- wastes,neem oil/garlic bulb extract/ custard apple extract with respect to control. Combination of vermiwash with bio pesticide caused early flowering possibly due to presence of TKN and TP in vermiwash which stimulates early flowering of crops[14,15,48,49,50].

There was significant reduction in flowering period of tomato in all the combination of vermicomposts of different animal and agro wastes + neem oil/garlic/custard apple extract with respect to control. The combination of vermicompost with biopesticide caused early flowering of tomato plants, possibly due to the presence of TKN, TP in the vermicompost which stimulate the early flowering of crop[14,15,48,49,50]. The rich amount of TKN and TP stimulate the early flowering period of *Daucuscarota* and tomato[6,62]

The significant increase in productivity of brinjal was observed in all the combination of vermiwash obtained from different combination of animal dung and MSW with neem plant parts. The significant maximum productivity of brinjal(7.16±0.59) was obtained after aqueous foliar spray application of combination of vermiwash derived from buffalo dung and MSW with neem oil. The combination of buffalo dung +gram bran with aqueous extract of garlic and neem oil shows significant maximum productivity of tomato, it is due to the presence of essential nutrients in vermicompost which increased the metabolic activity of plant as well as garlic extract check the tomato infestation of nematodes[33,48].Large amount of humic acid were produced during vermicomposting which lowers the pH of soil and ultimately affect the productivity of plant[32].

The foliar spray of MSW vermiwash causes persistence of water droplet on the leaves surface which promotes the leaf thickness, increase photosynthetic activity, internodes growth, improved plant physiology and ultimately increase the yield[13,28].

Large amounts of humus produced by earthworm's activity also contributed for the higher productivity in gram plant[47]. Combination of buffalo dung +MSW with neem oil/garlic extract is very effective combination for growth and productivity of gram plant[43].Vermiwash, the extracted body fluid of earthworms is also nutrient rich with components promoting good plant growth and productivity[10,11,46,48]. Mishra *et al*[42].,reported that vermicompost had beneficial effects on growth and yield of rice, especially caused significant increase of many growth parameters, seeds germination and yield. Sobha *et al*[69]., observed a significant growth and productivity in the black gram. Edwards *et al*[27]., have been suggested that vermiwash influence the fruit quality.

Likewise Prabhu[57]reported presence of large number of beneficial microorganisms that help in plant growth and protects it from a number of infestations. It was also reported that vermiwash improves the germination percentage of the seeds and seedling vigour of seeds such as cowpea and paddy crops. The effect of vermiwash was tested on growth of Cowpea plant on soil extract agar medium at laboratory scale experiments. The growth pattern was observed up to 15 day only.Vermiwash supplemented medium showed high Cowpea plant growth as compared to without supplementation. George *et al*[30]., reported the effect of vermiwash spray have significant maximum dry chilli yield. Thangavel[72] observed that both growth and yield of paddy increased with the application of vermiwash and vermicast extracts.

CONCLUSION

It is clear from the results that the foliar application of different combinations of vermiwash with neem plant parts have significant effect on growth , flowering , productivity, as well as their pest infestation of brinjal crops. The use of vermiwash with biopesticides is a best alternative of chemical fertilizer and synthetic pesticides. Vermiwash and biopesticidse are easily pre-parable, biodegradable, less expensive, most effective, non hazardous to animal, human and environment. The use of biofertlizers with biopestcides is eco-friendly and boon for farmers.

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