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Combined Effect of Vermiwash with Biopesticides Against Infestation of Pod Borer (*Helicoverpa armigera* Hub.)

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Abstract: Vermiwash singly and in combination with different biopesticides were used in agricultural field for management of the pod borer (*Helicoverpa armigera*) infestation and increase the growth and yield of gram (*Cicer arietinum*) crop. Significant reduction in the number of infected pods observed on the plant after spraying of vermiwash obtained from different combination of animal dung and agro wastes with neem (*Azadirachta indica*) oil, custard apple (*Annona squamosa*) leaves and garlic (*Allium sativum*). Vermiwash obtained from animal dung with gram bran with neem oil was also highly effective against the pod borer (*H. armigera*). Spray of vermiwash with biopesticide increased the productivity of gram crop up to 3 times with respect to control. Present study revealed that the use of vermiwash with plant product is more applicable in organic farming. It is helpful to balance the deficiency of essential nutrients along with certain plant growth hormones, enzymes and vitamins. Vermiwash and its combination with plant products were effective against pod borer which are injurious to the gram plant.

Key words: Pod borer, biopesticide, *Cicer arietinum*, *Eisenia foetida*, productivity, vermiwash.

Introduction

Gram is one of the important pulse crops of India. Seed contains 1.17% protein, 5.3% fat, 61.2% carbohydrates, 3.9% fibres and 2.7% minerals. It is very nutritive and used as protein adjunct to starchy diet (Singh et al., 2005). To increase the productivity of crops and management of pest by abundant use of chemical fertilizers and synthetic pesticide is one of the serious issues to the environment and human health (Mall et al., 2005). Kranthi et al., (2002) reported that indiscriminate use of insecticide against

various insect pest developed high level of resistance to conventional insecticide. The regular cropping of land without incorporation of organic matter caused deterioration of the soil quality (Devi, 2007). Management of soil quality, by the use of the organic fertilizer is a need of today. Vermiwash is a useful product of vermiculture which contains micronutrients, vitamins, hormones, and disease resistance power (Pathak and Ram, 2004). It is liquid organic biofertilizer, having pesticidal properties (Shivsubramaniam and

Ganeshkumar, 2004; Umamaheswari et al., 2003). Gamaley et al., (2006) have suggested that vermiwash is foliar manure and optimized the productivity of various agricultural crops.

Helicoverpa armigera is the member of family Noctuidae of order Lepidoptera. It is a serious pest of gram and other species of Leguminosae. It is polyphagous insect and feed on several agricultural crops belonging to family Poaceae, Papilionaceae, Solanaceae and Malvaceae are most preferred such as Pigeon peas, Beans, Soybeans, Sunflower etc (Sharma, 2001). The caterpillars are polyphagous in nature and causes heavy damage to gram and red gram. The pest feed on young pods foliage and seed resulting in reduced yield of crop. The caterpillars cut the flowers, pods and damage up to 90% of the total production (Shukla and Upadhyay, 2007).

The foliar spray of organic material for the management of *H. armigera* and increase the production of crop is one of the appropriate techniques of organic farming. Different plant (neem, garlic and custard apple) parts have pesticidal properties (Gupta and Sharma, 1993; Akhtar, 2004; Akhtar and Mahmood, 2004). Pavela et al. (2004) suggested that azadirachtin significantly increases the mortality but decreases the development and fecundity of cabbage aphid (*Brassicorhynchus brassicae*). Garlic produced a variety of volatiles sulphur compound which are used as insect repellent and insecticide (Gareth et al., 2006; Park et al., 2006). Different products of garlic which are recognized as insecticide are also used against mites, nematodes, mosquitoes larvae affecting a variety of crop (Gupta and Sharma, 1993; Gambola-Leon et al., 2006). The different combination of neem and custard apple seed oil effective against the survival of *Nephotettix virescens*

causes the distribution and transmission of rice tungro virus (Epino and Saxena, 1982; Mariappan et al., 1982; Mariappan and Saxena, 1983; Mariappan et al., 1988; Narasimhan and Mariappan, 1988). Rajput et al. (2003) reported that different plant products like Neemokill, Neem peth (*Azadirachta indica*), Turmeric (*Curcuma longa*) and sweetflag (*Acorus calamaus*) are effective against *H. armigera* with respect to non-treated group. Gilani (2001) reported that neem plant extract repel insects and deter their feeding. Growth and development of insects are also disturbed when feeds on the material treated with its extract.

The aim of the present study is to explore the effects of vermiwash of different animals (cow, buffalo, sheep, goat and horse) dung and agro/kitchen waste singly as well in combination with different plant products against pod borer (*H. armigera*) and their effects on growth, flowering as well as productivity of gram.

Materials and Methods

1. Collection of wastes:

Animal (cow, buffalo, sheep, horse and goat) dung were collected from different farm houses of the Gorakhpur city. Different agro wastes (gram bran, straw, wheat bran, barley bran and rice bran) and vegetable wastes were collected from rural and urban parts of Gorakhpur district. Partially decomposed mixtures of animal dung and agro/kitchen wastes were used for enhancement of vermicomposting efficiency. For this purpose, the mixture of organic wastes sprayed in a layer of 30-60 cm and exposed to sun light for 5 to 10 days to remove the various harmful organism and noxious gases (Bhatnagar and Palta, 1998).

2. Collection of earthworms

Earthworm *E. foetida*, an epigeic species, were cultured in laboratory conditions, temperature (20 to 30°C), moisture (40 - 60%) and aeration, for proper growth and survival of earthworms by the method of Gupta and Sharma (1993).

3. Preparation of vermicomposts

Vermicomposting conducted on cemented earth surface. The 35 vermibeds were formed by different combinations of animal dung with agro/vegetable wastes in 1:1 ratio (w/w). This is an appropriate ratio for proper development of earthworms. The size of each vermibed is 3m × 1m × 9cm. After preparation of vermibed, it was moistened and inoculated with 2kg cultured young *E. foetida* in each bed. The beds were covered with tore and useless jute pockets and moisten the bed daily up to 40 to 50 days for maintaining the moisture content. After one week interval, mixture of bed was manually turned-over up to 3 weeks. After 50 to 60 days granular tea like material i.e. vermicompost appear on each vermibeds.

4. Extraction of vermiwash

Vermiwash extracted using vermiwash collecting device by the method of Ismail (1997). The apparatus was made from plastic drum having capacity of 2 L and a tap at the bottom. The drum was filled with broken bricks, about 3cm thickened which is followed by sand layer of 2-3 cm thickness and lastly filled with vermicompost and heavy population of earthworms. Fresh water was added into the drum and a container kept below the tap of drum. The aqueous extract of vermicomposts leaches out off drum by the tap. The colour of vermiwash ranges from

yellowish to black. The extraction has been completed within 1 to 2 days.

5. Collection and preparation of biopesticide

5. 1. Neem oil

Neem oil-Azadirachtine, 00.03%; neem oil, 90.57%; Hydroxy El, 05.00% ; Epichlorohydrine 00.50 %; Aromax, 03.9%; Multiplex agricare Pvt. Ltd.

5. 2. Garlic extract

Aqueous extract of garlic obtained from *Allium sativum* bulb. Prepared aqueous extract (10g/100ml) (w/v) was mixed with diluted vermiwash in 1:10 ratio.

5. 3. Custard apple

Leaves were collected from plant of Custard apple (*Annona squamosa*). It is a native of South America and West Indies. Prepared aqueous extract (100g/100ml) (w/v) of leaves was mixed with diluted vermiwash in 1:10 ratio.

6. Experimental setup for measurement of growth, observation of infected pods, flowering period and productivity

Measurement of growth, number of infected pods on the plant and productivity of crops were performed in the experimental field of vermiculture research centre, Department of Zoology, D.D.U. Gorakhpur University. The seeds of gram were showed directly in the cultivated soil. In the cultivated field, each square having the size of 1m² (1m × 1m) area seed of gram were showed in each square in equal amount. Freshly extracted vermiwash were diluted seven times with water. After 30 days vermiwash were sprayed over the crops as singly and in combination with different biopesticides. The control has given no treatment. Growth of crop was measured by auxanometer after 50 days

from date of sowing. Number of infected pods was counted carefully on each plant. Flowering period were observed in adult plants. After harvesting of each crops, productivity were calculated in kg/ meter².

7. Statistical analysis

The value is expressed as mean \pm SE of 6 replicates. Two way analysis of variance (ANOVA) was applied to determine the significant ($P < 0.05$) difference among the number of aphids in control and treated group. One way analysis of variance was applied to notice significant difference ($P < 0.05$) between growth and productivity of crop with respect to different combination of vermiwash (Sokal and Rohlf, 1973).

Results

The combination of vermiwash with biopesticides viz. neem (*Azadirachta indica*) oil, aqueous extract of garlic (*Allium sativum*) and leaves extract of custard apple (*Annona squamosa*) caused a significant ($P < 0.05$) reduction in pest infestation and increase in plant growth, early flowering and productivity of the gram. Significant reduction in the number of infected pods was observed on the plants which were treated with vermiwash containing biopesticides. Spraying of vermiwash obtained from different combination of animal dung + agro/kitchen wastes with different plant product caused time and dose dependent significant reduction in the number of infected pods on the gram plant (Table 1). The third treatment (10mg/m²) of each combination caused maximum reduction of pest (caterpillars of pod borers). The combination of vermiwash with neem oil and with garlic extract was highly effective against pod borer (*H. armigera*) after third treatment and shows approximately 95-97% non-infected pods (Tables 2, 3). The

combination of vermiwash with leaf extract of custard apple also showed (20.00%) significant reduction of infected pods after third treatment with respect to control group i.e. 92.14% (Table 4). The different combinations of garlic extract + vermiwash and neem oil + vermiwash of different animal dung + gram bran caused the complete control of pod borer infestation on gram plant (Tables 2, 3).

Growth of gram plant in control group was 16.20 \pm 2.6 cm after 50 days of sowing. Three foliar spray of vermiwash obtained from different animal dung + agro/kitchen wastes with different biopesticides significantly increase in growth of gram plant. The highest growth of gram (43.85 \pm 2.7 cm) was observed by the foliar spray of vermiwash of buffalo dung + gram bran with garlic extract, followed by vermiwash of buffalo dung + gram bran with neem oil (Tables 2, 3).

The flowering period of gram in control group was 49.3 \pm 2.5 days. Significant early flowering was observed in all combinations of vermiwash of different animal dung + agro/kitchen wastes singly, and binary form with different biopesticides. The maximum significant early flowering period of gram was 28.4 \pm 2.1 and 28.8 \pm 2.6 days has been observed in combination of vermiwash of buffalo dung + gram bran with garlic extract/neem oil (Tables 2, 3).

The significant increase in productivity of gram was observed in all the combinations of vermiwash of different animal dung, agro/kitchen wastes singly and in combination with neem oil, garlic extract and leaf extract of custard apple. The combinations of buffalo dung + gram bran with aqueous extract of garlic bulb have maximum productivity of gram in comparison to all the biopesticide (Tables 2, 3).

Table 1: Effect of vermiwash (10 mg/m²) of different animal dung and agro / kitchen wastes against the infestation of pod borer and growth as well as flowering productivity of gram (*Cicer arietinum*).

Vermiwash	Total no. of pods	% infected pods of gram			Growth of gram (cm.) After 50 days	Flowering period (Days)	Productivity (kg/m ²) After harvesting
		After first spraying	After second spraying	After third spraying			
Control	56±2.2	50.60	78.42	92.14	16.20±2.6	49.3±2.4	0.15±0.03
Cow							
Dung	# 80±6.2	18.12	21.42	22.16	#30.00±2.4	39.1±1.4*	# 0.24±0.02
Dung +Rice Bran	\$ 82±4.3	16.18	19.13	21.02	28.12±3.2	38.2±3.2*	0.95±0.03
Dung +Wheat Bran	82±4.1	16.02	18.06	22.42	27.46±1.6	38.3±2.3*	0.22±0.24
Dung +Straw	84±6.2	17.04	20.25	23.36	35.25±1.6	35.2±3.2*	0.29±0.03
Dung +Vegetables	83±2.8	15.06	18.24	21.42	24.68±2.4	34.3±2.5*	0.22±0.03
Dung +Barely Bran	84±3.2	15.15	18.32	21.00	24.24±1.2	36.2±3.2*	0.21±0.04
Dung +Gram Bran	85±5.5	14.25	17.25	20.16	26.24±2.6	32.5±2.6*	0.26±0.04
Buffalo							
Dung	# 130±6.1	12.46	14.88	17.25	# 30.20±2.7	35.2±1.4*	# 0.25±0.03
Dung +Rice Bran	\$ 135±6.2	11.26	14.02	18.00	27.15±2.2	35.2±1.4*	0.26±0.03
Dung +Wheat Bran	136±8.2	11.26	14.22	17.16	32.00±2.6	32.6±2.5*	0.27±0.04
Dung +Straw	138±7.3	12.00	15.06	18.26	33.41±2.2	30.2±2.6*	0.24±0.04
Dung +Vegetables	138±6.4	11.28	14.26	17.64	28.21±2.4	34.2±1.6*	0.25±0.02
Dung +Barely Bran	136±6.1	11.25	13.86	16.02	34.21±2.5	30.2±1.4*	0.26±0.04
Dung +Gram Bran	140±5.4	10.12	13.25	16.65	36.25±1.6	29.0±2.2*	0.28±0.05
Sheep							
Dung	# 102±5.2	20.16	23.60	25.26	# 30.16±2.6	40.2±1.6*	# 0.25±0.04
Dung +Rice Bran	\$ 06±6.3	20.00	23.42	26.68	28.24±2.8	39.3±2.6*	0.23±0.05
Dung +Wheat Bran	106±2.5	16.86	20.23	23.06	34.46±3.8	36.2±3.6*	0.24±0.04
Dung +Straw	105±6.1	18.46	21.64	23.04	27.32±2.6	37.2±1.6*	0.22±0.03
Dung +Vegetables	108±5.2	19.16	22.00	24.86	32.64±2.4	38.2±1.2*	0.25±0.03
Dung +Barely Bran	98±2.1	16.14	19.42	23.46	32.14±2.8	37.8±2.6*	0.26±0.03
Dung +Gram Bran	100±7.2	17.34	20.12	23.12	33.4±21.6	35.6±2.4*	0.27±0.02
Goat							
Dung	# 101±7.3	21.42	23.68	25.25	# 28.42±2.8	42.8±2.6*	# 0.23±0.03
Dung +Rice Bran	\$ 107±2.4	20.46	23.25	25.68	30.00±2.5	40.2±3.6*	0.25±0.03
Dung +Wheat Bran	104±6.2	20.00	23.16	24.82	29.64±1.2	39.3±2.5*	0.24±0.04
Dung +Straw	103±6.3	19.25	21.26	23.13	31.23±2.4	39.3±2.5*	0.22±0.03
Dung +Vegetables	102±8.3	16.46	19.25	21.45	33.25±3.4	41.6±5.0*	0.23±0.04
Dung +Barely Bran	108±7.1	20.25	23.16	25.26	33.64±2.5	40.2±1.6*	0.26±0.03
Dung +Gram Bran	110±8.2	16.32	23.14	25.26	34.23±2.8	36.2±3.2*	0.26±0.04
Horse							
Dung	# 121±10.2	14.26	16.06	18.25	# 26.23±3.3	34.3±2.5*	# 0.26±0.02
Dung +Rice Bran	\$ 118±12.1	14.36	17.32	19.46	31.62±2.4	32.6±3.2*	0.23±0.03
Dung +Wheat Bran	118±6.2	12.42	15.60	19.20	33.52±2.6	33.3±3.2*	0.26±0.04
Dung +Straw	120±5.5	13.36	16.46	19.21	31.64±1.5	35.3±1.4*	0.23±0.07
Dung +Vegetables	122±1.5	18.42	21.25	23.68	32.72±2.3	32.0±2.5*	0.24±0.04
Dung +Barely Bran	125±7.5	15.12	18.24	21.32	33.15±2.5	36.0±1.6*	0.23±0.03
Dung +Gram Bran	128±7.8	14.24	17.26	20.25	35.25±2.5	32.3±2.6*	0.27±0.04

Each value is the mean ± SE of six replicates.
 2way ANOVA: Significant (P<0.05) \$ within column, # within row.
 * Significant (P<0.05, 't' test) between treated and control group.

Table-2: Effect of vermiwash of different animal dung and agro / kitchen wastes (10mg/m²) with neem oil (10:1) against the infestation of pod borer as well as growth and productivity of gram (*Cicer arietinum*).

Vermiwash	Total no. of pods	% infected pods of gram			Growth of gram(cm.)	Flowering period (Days)	Productivity (kg/m ²) After harvesting
		After first spraying	After second spraying	After third spraying	After 50 days		
Control	56±2.2	50.60	78.42	92.14	16.20±2.6	49.3±2.4	0.15±0.03
Cow							
Dung	# 78±2.4	10.12	11.20	11.56	# 33.32±6.2	38.2±2.2*	# 0.36±0.02
Dung +Rice Bran	\$ 80±2.5	08.62	09.12	09.66	31.34±2.4	37.3±3.2*	0.36±0.02
Dung +Wheat Bran	82±3.6	08.25	08.69	09.12	30.06±2.8	37.4±3.1*	0.37±0.05
Dung +Straw	81±3.6	06.21	06.52	06.96	32.25±2.5	34.3±1.2*	0.38±0.06
Dung +Vegetables	75±4.2	08.22	08.86	09.22	30.35±7.2	34.0±3.2*	0.39±0.04
Dung +Barely Bran	72±2.4	07.25	07.68	08.02	32.03±2.5	35.8±3.1*	0.40±0.03
Dung +Gram Bran	82±4.7	06.32	06.64	07.00	33.12±2.5	31.8±2.6*	0.42±0.03
Buffalo							
Dung	# 128±8.0	09.25	09.55	09.96	#33.28±6.2	34.3±2.1*	# 0.38±0.04
Dung +Rice Bran	\$ 132±6.2	08.28	08.58	09.00	33.89±2.5	31.3±2.5*	0.39±0.06
Dung +Wheat Bran	138±2.2	06.25	06.65	07.12	34.68±2.5	32.0±1.6*	0.39±0.02
Dung +Straw	132±6.3	06.25	06.89	07.20	30.63±2.5	30.0±2.5*	0.41±0.03
Dung +Vegetables	138±6.7	05.25	05.50	05.62	40.20±2.5	33.6±2.3*	0.40±0.03
Dung +Barely Bran	140±4.4	05.00	05.50	05.75	40.52±3.6	30.0±3.1*	0.42±0.03
Dung +Gram Bran	142±3.2	04.25	04.50	04.50	42.32±4.2	28.4±2.1*	0.43±0.05
Sheep							
Dung	# 100±7.7	11.25	11.62	12.12	# 32.88±2.6	38.3±2.4*	# 0.30±0.06
Dung +Rice Bran	\$ 110±8.2	10.28	10.85	11.25	30.00±3.2	37.8±2.6*	0.35±0.05
Dung +Wheat Bran	108±9.1	09.26	09.68	10.12	37.32±2.5	35.2±1.3*	0.36±0.02
Dung +Straw	102±2.5	09.86	10.22	10.52	30.50±3.8	36.4±2.5*	0.32±0.05
Dung +Vegetables	103±4.6	08.88	09.26	09.65	36.25±2.5	37.2±1.3*	0.37±0.06
Dung +Barely Bran	104±2.3	06.25	06.86	07.02	35.68±4.2	34.3±2.6*	0.38±0.02
Dung +Gram Bran	109±3.4	07.25	07.62	08.12	37.22±4.2	41.2±2.3*	0.41±0.08
Goat							
Dung	# 104±2.6	11.68	12.00	12.12	# 32.42±3.6	40.0±3.1*	# 0.31±0.02
Dung +Rice Bran	\$ 110±3.4	10.23	10.46	10.86	33.02±4.2	38.3±2.3*	0.32±0.03
Dung +Wheat Bran	108±2.6	09.89	10.10	10.46	33.14±3.2	38.2±2.6*	0.35±0.04
Dung +Straw	106±3.8	08.25	08.58	08.88	35.12±2.5	40.0±2.4*	0.36±0.06
Dung +Vegetables	110±2.5	08.62	08.98	09.25	36.22±2.5	39.6±1.3*	0.34±0.04
Dung +Barely Bran	102±3.8	07.89	08.00	08.06	37.25±3.5	35.2±2.5*	0.38±0.03
Dung +Gram Bran	112±4.8	07.22	07.35	07.82	38.42±2.6	35.0±3.2*	0.40±0.03
Horse							
Dung	# 112±2.5	09.25	09.62	09.89	# 29.16±2.6	33.3±2.5*	# 0.35±0.03
Dung +Rice Bran	\$ 114±3.5	06.68	06.98	07.12	35.36±3.2	31.3±2.6*	0.38±0.06
Dung +Wheat Bran	120±2.6	08.25	08.52	08.88	33.24±8.2	34.2±1.6*	0.37±0.07
Dung +Straw	118±3.5	07.22	07.52	07.98	35.25±2.5	31.3±2.4*	0.37±0.04
Dung +Vegetables	116±2.8	07.23	07.52	07.98	36.26±3.4	35.2±2.1*	0.36±0.03
Dung +Barely Bran	118±2.5	08.28	08.60	09.20	36.24±2.8	35.3±1.5*	0.37±0.04
Dung +Gram Bran	122±3.8	05.25	05.62	05.20	39.32±2.6	31.6±2.5*	0.40±0.04

Each value is the mean ± SE of six replicates.
 2way ANOVA: Significant (P<0.05) \$ within column, # within row.
 * Significant (P<0.05, 't' test) between treated and control group.

Table-3: Effect of vermiwash of different animal dung and agro / kitchen wastes (10mg/m²) with aqueous extract of garlic bulb (1:1) against the infestation of pod borer as well as growth and productivity of gram (*Cicer arietinum*).

Vermiwash	Total no. of pods	% infected pods of gram			Growth of gram (cm.) After 50 days	Flowering period (Days)	Productivity (kg/m ²) After harvesting
		After first spraying	After second spraying	After third spraying			
Control	56±2.2	50.60	78.42	92.14	16.20±2.6	49.3±2.4	0.15±0.04
Cow							
Dung	# 80±4.2	09.68	10.25	10.56	#30.12±3.4	38.4±2.4*	# 0.30±0.03
Dung +Rice Bran	\$ 84±6.3	08.56	08.98	09.20	32.25±4.3	36.8±2.5*	0.36±0.05
Dung +Wheat Bran	83±2.3	08.28	08.58	08.86	32.62±6.4	36.3±2.4*	0.37±0.04
Dung +Straw	81±6.2	06.66	06.85	07.12	35.25±3.4	34.3±2.5*	0.38±0.03
Dung +Vegetables	80±2.5	08.56	08.98	09.25	36.25±2.4	33.8±3.2*	0.38±0.03
Dung +Barely Bran	81±3.1	07.56	07.72	08.00	32.33±3.3	34.8±3.6*	0.40±0.03
Dung +Gram Bran	85±2.4	06.12	06.25	06.50	33.32±2.5	30.6±2.5*	0.42±0.06
Buffalo							
Dung	# 122±6.2	09.63	09.88	10.10	# 33.22±2.6	34.2±2.5*	# 0.38±0.03
Dung +Rice Bran	\$ 130±4.2	08.32	08.68	08.95	30.42±3.6	32.3±2.6*	0.40±0.07
Dung +Wheat Bran	132±3.4	06.25	06.55	06.82	34.25±2.8	31.6±2.5*	0.39±0.02
Dung +Straw	133±4.6	08.62	08.98	09.20	38.00±2.5	30.3±2.5*	0.40±0.04
Dung +Vegetables	135±6.2	06.32	06.65	06.95	39.22±2.5	31.5±2.6*	0.42±0.03
Dung +Barely Bran	140±6.2	05.12	05.46	05.75	42.22±2.3	34.5±1.5*	0.46±0.04
Dung +Gram Bran	142±2.5	04.50	04.88	05.20	43.85±2.7	28.8±2.6*	0.47±0.03
Sheep							
Dung	# 101±4.3	11.63	11.98	12.20	# 33.25±3.2	37.3±2.5*	# 0.31±0.02
Dung +Rice Bran	\$ 06±2.4	10.32	10.68	10.95	30.72±2.2	36.3±3.2*	0.35±0.06
Dung +Wheat Bran	104±3.2	09.38	09.72	10.08	37.32±3.8	36.2±1.2*	0.35±0.07
Dung +Straw	102±4.6	08.86	09.12	09.60	30.80±3.7	35.2±2.5*	0.36±0.02
Dung +Vegetables	100±3.2	08.72	08.98	09.23	36.42±2.8	34.2±3.2*	0.37±0.06
Dung +Barely Bran	108±2.5	05.32	05.68	05.98	37.22±2.2	40.2±3.6*	0.35±0.05
Dung +Gram Bran	110±2.8	07.42	07.88	08.15	27.32±2.5	44.2±3.6*	0.38±0.05
Goat							
Dung	# 102±3.8	11.32	11.72	11.32	# 30.34±2.8	39.0±2.6*	# 0.30±0.02
Dung +Rice Bran	\$ 104±2.5	11.00	11.25	11.52	33.28±2.6	38.8±3.2*	0.33±0.05
Dung +Wheat Bran	106±4.3	10.23	10.53	10.98	32.25±4.2	38.2±2.4*	0.35±0.02
Dung +Straw	103±4.6	09.38	09.49	09.68	38.02±2.8	39.3±3.6*	0.32±0.06
Dung +Vegetables	106±6.2	09.25	09.62	09.72	38.22±3.6	34.2±2.4*	0.36±0.07
Dung +Barely Bran	108±3.2	08.68	08.98	09.00	37.25±2.2	36.3±2.5*	0.37±0.08
Dung +Gram Bran	105±5.4	07.32	07.65	07.98	38.25±2.5	34.2±2.5*	0.38±0.06
Horse							
Dung	# 104±3.6	09.36	09.45	09.64	# 33.53±3.6	33.6±3.2*	# 0.36±0.05
Dung +Rice Bran	\$ 105±4.2	06.25	06.32	06.32	33.64±3.4	30.2±2.5*	0.38±0.02
Dung +Wheat Bran	108±3.4	05.34	05.42	06.42	35.67±2.5	33.8±3.2*	0.36±0.05
Dung +Straw	110±2.5	06.48	06.82	06.82	37.31±4.2	30.2±3.1*	0.35±0.06
Dung +Vegetables	110±3.2	06.88	07.48	07.53	38.00±2.3	34.6±3.6*	0.32±0.04
Dung +Barely Bran	112±4.6	07.25	07.42	07.62	38.00±8.2	35.3±2.5*	0.39±0.06
Dung +Gram Bran	115±3.4	05.35	05.52	05.52	39.20±2.4	30.5±2.5*	0.41±0.06

Each value is the mean ± SE of six replicates.
 2way ANOVA: Significant (P<0.05) \$ within column, # within row.
 * Significant (P<0.05, 't' test) between treated and control group.

Table-4: Effect of vermiwash of different animal dung and agro / kitchen wastes (10mg/m²) with aqueous extract of garlic bulb (1:1) against the infestation of pod borer as well as growth and productivity of gram (*Cicer arietinum*).

Vermiwash	Total no. of pods	% infected pods of gram			Growth of gram (cm.) After 50 days	Flowering period (Days)	Productivity (kg/m ²) After harvesting
		After first spraying	After second spraying	After third spraying			
Control	56±2.2	50.60	78.42	92.14	16.20±2.6	49.3±2.4	0.15±0.03
Cow							
Dung	# 82±3.2	25.12	28.14	30.26	# 31.00±2.3	39.6±1.2*	# 0.30±0.04
Dung +Rice Bran	\$ 83±4.2	22.21	26.34	28.25	29.22±1.6	35.2±1.6*	0.28±0.03
Dung +Wheat Bran	86±4.8	22.34	24.32	26.26	28.23±2.5	38.5±1.6*	0.32±0.04
Dung +Straw	89±2.6	21.23	25.24	28.46	38.72±3.2	35.2±2.5*	0.30±0.03
Dung +Vegetables	83±2.6	26.35	28.68	31.25	32.00±2.4	36.2±1.4*	0.28±0.05
Dung +Barely Bran	80±2.5	22.46	25.15	28.00	30.72±3.2	36.8±2.6*	0.27±0.03
Dung +Gram Bran	88±2.5	20.12	23.00	27.34	31.24±2.4	33.4±2.5*	0.35±0.04
Buffalo							
Dung	# 132±3.4	20.38	22.25	24.26	# 31.24±2.8	36.4±3.6*	# 0.30±0.04
Dung +Rice Bran	\$ 128±4.6	18.25	21.13	21.23	30.42±3.1	36.2±1.6*	0.31±0.06
Dung +Wheat Bran	134±6.6	16.26	18.53	21.00	32.41±2.4	35.3±1.8*	0.35±0.06
Dung +Straw	135±2.5	15.86	17.24	20.12	28.25±2.6	32.4±2.6*	0.40±0.06
Dung +Vegetables	138±2.5	18.21	21.56	23.55	38.72±2.4	31.5±2.5*	0.33±0.02
Dung +Barely Bran	134±4.6	17.56	19.25	21.62	38.46±2.8	32.5±1.6*	0.32±0.03
Dung +Gram Bran	144±2.6	15.00	17.25	20.00	40.34±3.8	30.2±2.5*	0.36±0.04
Sheep							
Dung	# 104±3.6	25.43	27.35	30.12	# 31.41±2.4	42.3±2.5*	# 0.22±0.03
Dung +Rice Bran	\$ 108±2.6	26.21	28.68	30.68	28.24±2.6	41.3±3.5*	0.30±0.03
Dung +Wheat Bran	112±3.6	27.32	20.32	23.46	35.21±2.6	41.2±1.6*	0.29±0.05
Dung +Straw	104±3.6	24.31	27.63	30.12	28.25±1.6	35.0±2.5*	0.28±0.05
Dung +Vegetables	116±2.6	25.21	28.26	31.25	34.72±6.4	35.2±3.5*	0.28±0.04
Dung +Barely Bran	120±3.9	23.53	26.28	29.32	34.25±3.2	37.2±2.8*	0.30±0.07
Dung +Gram Bran	124±2.4	21.25	24.25	27.16	35.27±2.4	34.2±2.5*	0.32±0.04
Goat							
Dung	# 106±3.6	24.21	26.46	29.46	# 30.42±3.8	42.8±2.5*	# 0.22±0.07
Dung +Rice Bran	\$ 104±3.2	23.34	26.00	29.25	31.26±2.5	40.3±2.8*	0.24±0.05
Dung +Wheat Bran	108±4.4	22.12	25.31	28.62	30.25±3.2	41.8±3.2*	0.28±0.03
Dung +Straw	112±2.6	23.32	26.16	29.46	35.25±4.6	39.3±3.8*	0.32±0.04
Dung +Vegetables	115±3.6	22.16	25.32	28.68	35.32±3.4	38.2±2.6*	0.22±0.03
Dung +Barely Bran	118±4.2	24.25	27.14	29.98	25.24±4.2	37.2±2.5*	0.28±0.03
Dung +Gram Bran	120±2.6	21.22	24.62	27.16	36.50±3.2	35.2±3.2*	0.31±0.02
Horse							
Dung	# 128±2.6	20.46	22.14	25.16	# 28.23±3.6	34.8±3.3*	# 0.28±0.02
Dung +Rice Bran	\$ 125±3.8	18.22	20.62	22.22	33.42±3.4	32.4±2.6*	0.32±0.04
Dung +Wheat Bran	135±4.6	20.00	22.46	24.25	31.52±3.2	34.2±1.8*	0.33±0.06
Dung +Straw	130±3.2	18.16	20.22	23.64	33.53±5.2	33.1±3.4*	0.30±0.06
Dung +Vegetables	140±2.4	17.32	20.00	24.16	35.43±3.2	32.2±3.2*	0.32±0.07
Dung +Barely Bran	135±4.2	16.25	19.16	22.24	36.43±2.4	34.2±2.5*	0.30±0.04
Dung +Gram Bran	140±2.6	16.00	17.02	19.36	37.60±2.4	30.2±1.4*	0.34±0.02

Each value is the mean ± SE of six replicates.
 2way ANOVA: Significant (P<0.05) \$ within column, # within row.
 * Significant (P<0.05, 't' test) between treated and control group.

Discussion

From the results of present study it is clear that the use of vermiwash extracted from vermicompost obtained from different combinations of animal and agro/kitchen wastes singly as well as in combination with different biopesticide like neem (*Azadirachta indica*) oil, aqueous extract of garlic (*Allium sativum*) bulb and leaf extract of custard apple (*Annona squamosa*) (Nath et al., 2011; Nath and Singh, 2011; Pathak and Ram, 2004; Rajput et al., 2003; Sharma, 2001) caused significant reduction in economically harmful insect pest to various agricultural crops ultimately enhancing the growth, early flowering and productivity of gram crop. Vermiwash of different animal and agro wastes have significant amount of nitrogen, phosphorus, Ca⁺⁺, K⁺, vitamins, enzymes, plant growth hormones etc. (Kausik and Garg, 2003; Nath and Singh, 2009; Nath et al., 2009a, b) and plant pesticide viz. neem (*Azadirachta indica*) oil, aqueous extract of garlic (*Allium sativum*) bulb and leaf extract of custard apple (*Annona squamosa*) have toxic effect against pod borer infestation (Pavela and Barnet, 2004; Pavela et al., 2004). Hossain and Poehling (2006) reported that neem based insecticide Azal-T/S^R effective against different immature life stages of leafminer *Liriomyza sativae* (Diptera: Agromyzidae) on tomato. Application of different neem product is effective against various rice, wheat, pulses and vegetable pests (Prakash et al., 2008). Epino and Saxena (1982) reported that use of leaves and fruit extract of custard apple (*Annona squamosa*) is effective against green leaf hopper (*Nephotettix virescens*) and brown plant hopper (*Nilaparvata lugens*). The volatiles of neem seed kernel prevent the contact and repelled the moth of *Helicoverpa armigera*. The azadiractin was found to reduce feeding

rate of the larvae and increase the mortality of various insect pest (Weathersbee et al., 2005).

Vermiwash obtained from different vermicompost of animal dung +gram bran with neem oil and garlic extract have total control on pod borer infestation. The reduction of pod borer infestation may be due to the mortality of caterpillars. The chemical content found in the plant extract has the ability to cause mortality of caterpillars (Weathersbee et al., 2005). The highest growth of gram was observed by the spray of vermiwash obtained from buffalo dung +gram bran in all the combination with biopesticide. Vermiwash of these combinations are the rich source of enzymes, vitamins, plant growth hormones such as IAA (Indol acetic acid), Gibberelins, Cytokinin along with micro- and macro-nutrients and due to the presence of biopesticides which enhance the growth of plant (Pathak and Ram, 2004).

There was significant early flowering of gram in all the combinations of vermiwash obtained from different animal and agro wastes +neem oil/garlic bulb extract/custard apple extract with respect to control. The combination of vermiwash with biopesticide caused early flowering of gram plants, possibly due to the presence of TKN, TP in the Vermiwash which stimulate the early flowering of crop (Atiyeh, 2002; Nath and Singh, 2009; Nath et al., 2009a, b; Nath et al., 2011; Nath and Singh, 2011). It was found that rich amount of TKN and TP stimulate the early flowering of *Daucus carota* and mustard (Ali and Jahan, 2001; Satpal and Saimbhi, 2003). Ali and Jahan (2001) noticed similar result by use of vermicompost in Lady's finger (*Ablemoschus esculentus*).

The combination of buffalo dung +gram bran with aqueous extract of garlic

bulb and neem oil showed significant maximum productivity of gram, it is due to the presence of essential nutrients in vermiwash which increased the metabolic activity of plant as well as garlic bulb extract/neem oil reduced the pod borer infestation of gram plant (Ali and Jahan, 2001; Gareth et al., 2006). Large amount of humic acid was produced during vermicomposting which lowers the pH of vermicompost/vermiwash and ultimately affect the productivity of plant (Gupta, 2005). Buckerfield et al., (1999) have also reported that continuous application of vermiwash promotes early flowering and better productivity of radish. Reduction of *H. armigera* on plant directly affects the productivity of crops (Akhtar and Mahamood, 2004; Musabyimana and saxena, 2008).

From the present study it can be concluded that different combinations of vermiwash obtained from buffalo dung + gram bran with neem oil and aqueous extract of garlic is effective for the control of pod borer infestation on gram plant. Simultaneously, it also increases the growth, started early flowering and enhanced the productivity of gram up to three times with respect to control. The uses of each combination in the present study are easily producible, cheap, biodegradable and not injurious to environment as well as human health. Agricultural products produced from these biofertilizer and biopesticide will be ecologically safe and culturally most acceptable among public.

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