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Efficacy of Biorational Compounds against Whitefly (*Bemisia tabaci* Genn.) on Blackgram (*Vigna mungo* L.)

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ABSTRACT

Bio-rational compounds were evaluated against the field population of whitefly on blackgram in randomized complete block design replicated thrice during rainy season of 2012/13 and 2013/14 at GLRP, Rampur, Chitwan, Nepal. Altogether eight treatments, i.e. Rapid (Acetamiprid 20% SP) @ 0.5 gm/lt of water; Spinosad, (Tracer 45% SP) @ 0.25 ml/lt of water; Fighter (Cypermethrin 10% EC + Chloropyrifos 50% EC) @ 1.5 ml /lt of water Admire (Imidacloprid 25% WP) @ 0.25 g/lt of water, Nepal pepper (*Xanthoxylum armatum* DC.) fruit extract @ 1:5 part; Neem (*Azadirachta indica* A. Juss.) leaves extract @1:5 part; Jadu (Triazophos 25% EC + Deltamethrin 1% EC) @ 0.5 ml/lt of water; and one control (water spray) were selected for the experiment. Cumulative mean efficacy on population reduction over control, after third sprays indicated that spinosad (72.96%) and admire (60.97%) was very effective followed by jadu (59.54%), fighter (58.49%), and rapid (51.42%) with moderate efficacy. Neem (35.56%) and Nepal pepper (36.31%) extracts were the least effective in controlling whitefly population. The highest cost benefit ratio was found in plot treated with spinosad i.e. 1:2.7 followed by admire treated plots 1:2.6.

Keywords: Blackgram, bio-rational compound, efficacy, spinosad, whitefly

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INTRODUCTION

Pulses form an integral part of Nepalese farming system. They have a significant role in crop diversification, intensification and sustainable soil management (GLRP, 2011). Pulses rank 4th in acreage and 5th in production after rice, maize, wheat and millet in Nepal. They occupy about 10% of total cultivated land. Recent statistics (2013/014) showed that area, production and productivity of grain legumes were 328,738 ha, 352,473 metric tons and 1072 kg/ha, respectively in Nepal (MOAD, 2014). Among the different pulses, blackgram (*Vigna mungo* L.) is an important summer legume in mid hills and a rich source of protein, which is one of the essential nutrients of human diets (Singh *et al*., 2013). Blackgram contributes 5.5% to the national pulse production from an area of 7% (MOAD, 2014). The area under blackgram in Nepal is about 23,312 ha with production of 19,383 mt and productivity of 831 kg/ha during 2013/14 (MOAD, 2014). At present blackgram is the third most leading pulse crop in Nepal after lentil and soybean. There is a big gap between potential yield and actual yield of pulses due to various biotic, a-biotic and socioeconomic constraints in Nepal (Shrestha *et al*., 2011). Insect pests are the most important biotic constraint to the production of legumes in Nepal (GLRP, 2012). The crop is damaged by a number of insect pests during successive stages of the growth, right from root nodules to leaves, flowers, pods and even in seed during storage. Blackgram is attacked by more than two dozen insect pests, among them whitefly (*Bemisia tabaci* Genn.) cause the most serious damage (Nayar *et al*., 1976). It is considered as economical insect and a main pest in cropping system (Oliveira *et al*., 2001). It was first recorded as a pest of Malaysia in 1935 on blackgram, soyabean and okra at low lands (Corbett, 1935). It damages the crop by direct feeding through sucking cell sap in leaves strip vital nutrient, thus decreasing productivity and health of plant and also by indirect means producing sticky secretion (honey dew) that supports the growth of sooty moulds (Loopez and Cock, 1986). The avoidable losses due to whitefly and other insect pests in blackgram have been reported to rage from 17.42 to 71.00 % at different locations of India (Chhabra, 1992; Hassan *et al*., 1998; Saxena, 1983). It also transmits plant pathogenic virus (Yellow mosaic virus) and act as an efficient vector (Chu and Henneberry, 1998). Yellow mosaic virus was first reported in India in 1995 and obviously transmitted by whitefly. It infects blackgram, mungbean, soybean and cowpea and some other legumes hosts (Dhingra and Chenulu 1985; Qazi *et al*., 2007) It is reported to be the most destructive viral disease not only in Nepal, but also in India, Bangladesh, Srilanka and contiguous areas of south East Asia (Bakar, 1981; Biswass *et al*., 2008, John *et al*., 2008). The virus causes uneven yellow and green specks or patches on the leaves which finally turn entire yellow. Affected plants generate fewer flowers and pods, which also develop mottling and remain small and contain fewer, smaller and shrunken seeds. In whitefly which transmits YMV persistently, the adult females are more

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proficient transmitters than males. The whitefly obtains the virus from diseased leaves (Honda and Ikegami 1986).

For the management of insect pests, farmers mostly used ineffective, banned chemical pesticides with inappropriate methods which further added their losses (Thapa 2003; GC *et al.*, 2003). The indiscriminate use of insecticides causes phyto-toxicity and destruction of beneficial organisms, such as predators, parasitoids, microorganisms and pollinators (Hussain 1984; Luckman and Metcalf 1978). It is with this main reason, the present study was designed to evaluate the efficacy of bio-rational compounds against whitefly and their cost benefit analysis to find out certain alternative methods of whitefly management in legumes and reduce the pesticide load on the crop.

MATERIALS AND METHODS

The experiment was conducted at GLRP, Rampur, Chitwan under natural ephiphytotic condition following Randomized Complete Block Design with three replications. The geographical location of the experimental site is 27^{0}37' N latitude and 84^{0}25'E longitude at an altitude of 256 masl and has sub tropical climate. During blackgram growing seasons of 2013 and 2014, a susceptible local genotype 'Magalpur local' was sown on the second week of August in the unit plot size of 3m x 2m with the spacing of 50 cm x 10 cm. Treatments consisted of seven bio-rational compounds with different concentration and one control (water spray) as given below.

- T_1 Rapid (Acetamiprid 20% SP) @ 0.5 g/lt of water
- T_2 Spinosad (Tracer 45% SC) @ 0.25 ml/lt of water
- T_3 Fighter (Cypermethrin 10% EC + Chloropyrifos 50% EC) @ 1.5 ml/lt of water
- T_4 Admire (Imidacloprid 25% WP) @ 0.25 g/lt of water
- T_5 Water extract of *Xanthoxylum armatum* DC (Nepal Pepper-Timur) fruit @ 1:5 part
- T_6 Water extract of *Azadirachta indica* A.Juss (Neem) leaves @1:5 part
- T_7 Jadu (Triazophos 25% EC + Deltamethrin 1% EC) @ 0.5ml/lt of water
- T_8 Water spray (Control)

After sowing, the experiment was kept under constant supervision from sowing to harvest. Agronomic practices were followed as recommended (GLRP, 2012). The fertilizer dose was 20:40:20 (N:P:K) kg/ha. First spray was given after 15 days of sowing followed by three sprays at an interval of 10 days. Insect data was recorded before every spray from 25 randomly tagged plant/plots.

Whitefly population was counted by visual leaf inspection method. Pre-treatment observation was made before 24 hours of spraying. Post- treatment observations were recorded at 3rd,5th and 7th days after spraying. Population reduction over control (PROC%) was calculated by formula (Eq.1) develped by Fleming and Retnakaran (1985).

$$PROC\ (\%)=(1-\frac{Ta \times Cb}{Tb \times Ca})X\ 100 \qquad [Eq.1]$$

Where, T_a=Population in treatment after spray
T_b=Population in treatment before spray
C_a=Population in control after spray
C_b= Population in control before spray

Whitefly number reduction over control (WNROC %) was calculated by the following formula:

$$WNROC\ \% = \frac{\text{Whitefly number in control} - \text{Whitefly number in treatment}}{\text{Whitefly number in control}} \times 100 \qquad [Eq.2]$$

All the treatments were superior over control in whitefly reduction. The whitefly population was lower in blackgram plants sprayed with bio-rational compounds compared to control after first spray during both years, i.e. 2013 and 2014 (Table 1). Combined analysis of two consecutive years revealed that whitefly population at 5th and 7th days of spray were significantly different due to the effect of bio-rational compounds in both years. The Spinosad (Tracer 45% SC) sprayed plot (9.31 adults/plant) resulted in the lowest numbers as compared to control (water spray) (16.33 adults/plant). The higher whitefly population reduction was found in Spinosad (Tracer 45% SC) treated plots (43.00%) followed by Rapid (Acetamiprid 20% SC) i.e. (41.78%) over control.

Table 1: Effect of bio-rational compounds after first spray on whitefly population of blackgram at GLRP, Rampur, Chitwan, 2013-2014

Treatments	EPS	WNBS	WN3DS	WN5DS	WN7DS	Mean	WNROC %
Rapid @ 0.5 g/lt of water	†140.20	10.77	4.89^{b}	4.98^{c}	17.40^{bc}	9.51	41.78
Spinosad @ 0.25 ml /lt of water	137.70	11.81	4.52^{b}	4.35^{c}	16.56^{bc}	9.31	43.00
Fighter @ 1.5 ml/lt of water	137.30	12.05	4.61^{b}	4.80^{c}	17.67^{bc}	9.78	40.11
Admire @ 0.25 g/lt of water	138.80	16.85	6.70^{b}	5.72^{c}	12.13^{c}	10.35	36.63
X. armatum aq. extract (1:5)	138.30	13.64	10.85^{a}	9.77^{b}	19.11^{b}	13.34	18.31
A. indica aq. extract (1:5)	139.30	10.68	7.85^{ab}	8.77^{b}	16.78^{bc}	11.02	32.53
Jadu @ 0.5 ml/lt of water	137.00	13.31	4.97^{a}	6.48^{c}	14.71^{bc}	9.86	39.59
Control (water spray)	137.70	12.33	11.07^{a}	15.53^{a}	26.41^{a}	16.33	
A (First Year)	-	-	NS	**	**		
B (Second Year)	-	-	**	**	**		
A*B	-	-	NS	**	**		
	-	-	3.66	2.28	4.99		
CV %	1.66	36.16	31.66	18.14	17.03		

Means of three replications over two years. Mean values in column with the same superscripts are not significantly different by DMRT $_{(P>0.05)}$. EPS- early plant stand, WNBS- Whitefly number before spray, WNDS- Whitefly number days after spray (3,5&7), WNROC% - Whitefly number reduction over control, NS- Not significant, **- Highly significant (p>0.001)

Whitefly (*B. tabaci*) population after second spray (2013-2014)

After the second spray, the trend of whitefly population reduction was almost similar to the result after first spray. During second year (2014), the combined analysis showed that whitefly populations at 7th days after spray were significantly different due to the effect of bio-rational compounds (Table 2). The higher whitefly population reduction was noticed in Spinosad (Tracer 45% SC) treated plots (68.79%) followed by Admire (Imidacloprid 25% WP) (61.00%) over control (water spray).

Table 2: Efficacy of bio-rational compounds after second spray on whitefly population of blackgram at GLRP, Rampur, Chitwan, 2013-2014

Treatments	WNBS	WN3DS	WN5DS	WN7DS	Mean	WNROC (%)
Rapid @ 0.5 g/lt of water	†26.33^{bc}	19.45^{bcd}	16.39^{bc}	14.71^{bc}	19.22	50.38
Spinosad @ 0.25 ml /lt of water	18.58^{c}	11.41^{d}	10.00^{c}	8.36^{c}	12.08	68.79
Fighter @ 1.5 ml/lt of water	24.16^{bc}	18.96^{bcd}	17.44^{bc}	13.04^{c}	18.40	52.50
Admire @ 0.25 g/lt of water	23.48^{bc}	15.26^{cd}	12.54^{c}	9.14^{c}	15.10	61.00
X. armatum aq. extract (1:5)	32.48^{ab}	26.27^{b}	23.30^{b}	22.16^{b}	26.05	32.75
A. indica aq. extract (1:5)	28.66^{ab}	19.13^{bcd}	18.22^{bc}	14.94^{bc}	20.23	47.76
Jadu @ 0.5 ml/lt of water	24.57^{bc}	21.77^{bc}	16.23^{c}	14.80^{bc}	19.43	50.07
Control (water spray)	37.33^{a}	38.82^{a}	39.72^{a}	39.09^{a}	38.74	
A (First year)	NS	*	NS	NS		
B (Second year)	**	**	**	**		
A*B	NS	NS	NS	NS		
LSD (⩾ 0.05)	8.75	8.95	7.97	7.55		
CV%	19.49	25.11	24.86	26.61		

† Means of three replications over two years. Mean values in column with the same superscript are not significantly different by DMRT $_{(P>0.05)}$. WNBS- Whitefly number before spray, WNDS- Whitefly number days after spray (3,5&7), WNROC% - Whitefly number reduction over control, NS- Not significant, * - Significant **- Highly significant(p>0.001)

Whitefly (*B. tabaci*) population after third spray (2013-2014)

Combined analysis of two years data revelaed that whitefly population after interval of all 3rd, 5th and 7th days sprays were significantly different due to the effcets of bio-rational compounds in both years (Table 3). Selected five insecticides were significantly effective to supress whitefly population over control. Botanicals were less effective than chemical insecticides but better than control (water spray). Due to the effcet of first and second sprays of biorational compounds, the whitefly number before spray (WNBS) was also significantly

Table 3: Effect of bio-rational compounds after third spray against whitefly population on blackgram at GLRP, Rampur, Chitwan 2013-2014

Treatments	WNBS	WN3DS	WN5DS	WN7DS	Mean	WNROC (%)
Rapid @ 0.5 g/lt of water	†19.51^{b}	14.96^{cd}	10.37^{c}	6.40^{c}	12.81	47.29
Spinosad @ 0.25 ml /lt of water	24.98^{a}	13.20^{d}	6.17^{d}	3.24^{c}	11.89	51.04
Fighter @ 1.5 ml/lt of water	23.67^{a}	15.33^{cd}	10.61^{c}	6.95^{c}	14.14	41.82
Admire @ 0.25 g/lt of water	24.11^{a}	15.91^{cd}	9.34^{c}	6.25^{c}	13.90	42.79
X. armatum aq. extract (1:5)	24.06^{a}	19.50^{b}	16.86^{b}	14.94^{b}	18.84	22.48
A. indica aq. extract (1:5)	21.61^{ab}	17.26^{bc}	15.85^{b}	13.51^{b}	17.05	29.81
Jadu @ 0.5 ml/lt of water	23.70^{a}	15.22^{cd}	10.02^{c}	6.86^{c}	13.95	42.60
Control (water spray)	22.36^{ab}	22.96^{a}	24.65^{a}	27.25^{a}	24.30	
A (First year)	**	**	**	**		
B (Second year)	**	**	**	**		
A*B	**	**	**	**		
LSD (⩾ 0.05)	3.20	2.68	2.32	1.92		
CV%	8.36	9.58	10.73	10.79		

† Means of three replications over two years. Mean values in column with the same superscript are not significantly different by DMRT $_{(P>0.05)}$. WNBS- Whitefly number before spray, WNDS- Whitefly number days after spray (3,5&7), WNROC% - Whitefly number reduction over control, NS- Not significant, **- Highly significant(p>0.001)

different in both years (Table 3). The mean whitefly population was lower in Spinosad (Tracer 45% SC) sprayed plots (11.89 adults/plants) after third spray followed by Rapid (Acetamiprid 20% SP) (12.81 adults/plants) as compared to control (24.30 adults/plants). The higher number of whitefly reduction was noticed on Spinosad (Tracer 45% SC) treated plots (51.04%) followed by Rapid (Acetamiprid 20% SP) treated plots (47.29%) over control (Table 3). Grain yield and thousand seed weight both were significantly different due to the effects of treatments in both years (Table 4). The highest grain yield and population reduction over control both was obtained from the plots sprayed with Spinosad (Tracer 45% SC), 1561 kg/ha and 72.96% followed by Admire (Imidacloprid 25% WP) i.e. 1537 kg/ha and 60.97%, respectively. Thousand seed weight was also significantly higher in Rapid (Acetamiprid 20% SP) sprayed plots (47.17 g) followed by Admire (Imidacloprid 25% WP) sprayed plot (47.00 g). Germination of the seed obtained from Spinosad sprayed plot was found significantly higher (88.83%) (Table 4).

Table 4: Effect of bio-rational compounds after third spray on yield and yield attributes of blackgram at GLRP, Rampur Chitwan 2013-2014

Treatments	EPS	FPS	Yield (kg/ha)	TSWt (g)	GER (%)	YI (%)	PROC (%)
Rapid @ 0.5 g/lt of water	†140.20	138.20	1446.00^{c}	47.17^{a}	85.50^{abc}	102.63	51.42
Spinosad @ 0.25 ml /lt of water	137.70	135.70	1561.00^{a}	45.17^{bc}	88.83^{a}	118.75	72.96
Fighter @ 1.5 ml/lt of water	137.30	135.50	1472.00^{b}	45.33^{abc}	84.00^{c}	106.28	58.49
Admire @ 0.25 g/lt of water	138.80	137.20	1537.00^{ab}	47.00.^{ab}	87.00^{abc}	115.39	60.97
X. armatum aq. extract (1:5)	138.30	135.80	1189.00^{d}	44.67^{abc}	87.33^{ab}	66.62	36.31
A. indica aq. extract (1:5)	139.30	136.80.	1189.00^{d}	44.17^{c}	84.67^{bc}	66.62	35.56
Jadu @ 0.5 ml/lt of water	137.00	134.50	1496.00^{a}	44.67^{c}	85.00^{abc}	109.64	59.54
Control (water spray)	137.70	135.00	713.60^{e}	41.83^{c}	77.33^{d}		
A (First Year)	-	-	**	*	NS		
B (Second Year)	-	-	**	**	**		
A*B	-	-	NS	NS	NS		
LSD ($\geqslant$ 0.05)	-	-	48.80	2.56	3.16		
CV %	1.66	1.89	2.21	3.05	2.60		

† Means of three replications over two years. Mean values in column with the same superscript are not significantly different by DMRT $_{(P<0.05)}$. EPS- early plant stand, FPS- Final plant stand, Yield- Grain yield in kilogram per hectare, TSWt- Thousand seed weight in gram, GER%- Germination percentage, %YI- Percent yield increase, PROC% - Population reduction over control, g- gram. lt- litre, ml- millilitre, NS- Not significant, *- Significant (p>0.05), **- Highly significant (p>0.001)

Relationship between population reduction and yield increase over control

A positive linear correlation between population reduction over control (PROC) and percent yield increase was observed during two consecutive years, 2013-2014. Equation Y= 0.593X-4.562 and R^2= 0.932 gave the best fit (Fig. 1). It was noted that yield was increased with the decrease in whitefly population. Ghosh (2014) found that among the biopesticides, microbial toxin spinosad (*Saccharopolyspora spinosa*) was the most effective against whitefly and among chemicals; imidacloprid provided the best suppression of whitefly. The grain yield was also maximum in the plots treated with imidacloprid and spinosad (Ghosh 2014). The present findings can be compared with those Afzal *et al.* (2002) and Khan *et al.* (2012) who reported that imidacloprid was the most effective insecticide in suppressing the whitefly population but its continuous use resulted in increased whitefly populations. Shivanna *et al.* (2011) also found that insecticides dimethoate, imidacloprid, acetamiprid, triazophos and fenopropathrin were effective to control whitefly in cotton while biopesticides, like spinosad and econeem were also superior than control to suppress the whitefly population.

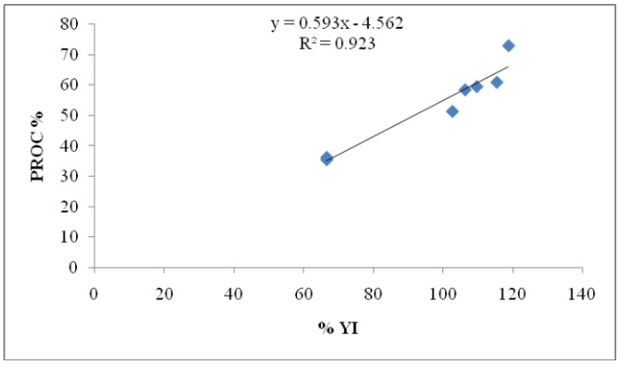

Fig. 1: Relationship between population reduction over control and percent yield increase after third spray at GLRP, Rampur, Chitwan, 2013-2014

Cost benefit ratio

The highest cost benefit ratio was found in plot treated with Spinosad (Tracer 45% SP) i.e. 1:2.7 followed by Admire

(Imidacloprid 25% WP) treat plots 1:2.6, Jadu (Triazophos 25% EC + Delatmethrin 1% EC) and Fighter (Cypermethrin 10% EC + Chloropyrifos 50% EC) i.e. 1:2.4. Similarly, cost benefit ratio of 1: 2.2 was noticed in plot treated with Rapid (Acetamiprid 20% SP) while the lower cost benefit ratio was recorded in plot treated with botanicals extract, i.e. 1:1.1 (Table 5). The similar findings on maximum cost benefit ratio was reported by Panghal *et al.* (2008) and Lal and Jat (2015) in mungbean who reported that maximum incremental cost benefit ratio was obtained in the plots sprayed with insecticide and biopesticide to control whitefly population.

Table 5: Cost benefit ratio of bio-rational compounds against whitefly on blackgram at GLRP, Rampur, Chitwan, 2013-2014

Treatments	Dose	SY (kg/ha)	ISYC (kg/ha)	*VISY/ ha (Rs)	CT3S/ha (Rs)	**LC/ ha (Rs)	OCC ha (Rs)	Total cost (Rs)	Net Return (Rs)	C:B Ratio
Rapid	0.5 g/lt	1446	733	43980	1076.3	4000	8500	13576.3	30403.7	1:2.2
Spinosad	0.25 ml/lt	1561	848	50880	1124.9	4000	8500	13624.9	37255.1	1:2.7
Fighter	1.5 ml/lt	1472	759	45540	745.6	4000	8500	13245.6	32294.4	1:2.4
Admire	0.25 g/lt	1537	824	49440	925.9	4000	8500	13425.9	36014.1	1:2.6
X. armatum	(1:5 part)	1189	476	28560	720.8	4000	8500	13220.8	15339.2	1:1.1
A. indica	(1:5 part)	1189	476	28560	692.7	4000	8500	13192.7	15367.3	1:1.1
Jadu	0.5 ml/lt	1496	783	46980	1084.2	4000	8500	13584.2	33395.8	1:2.4
Control		713	-	-	-	-	-	-	-	-

Note: SY- Seed yield, kg/ha- kilogram per hectare , ISYC- Increased seed yield over control, VISY- value of increased seed yield, Rs- Nepalese Rupees, CT3S: Cost of treatments for 3 sprays, LC- Labour Cost, OCC- Other cost of cultivation C:B- Cost/benefit, g-gram. lt- litre, ml-millilitre, Aq. E. – Aqueous extract, *Price of seed : Rs.60/kg, **Labour charge: 200/day

CONCLUSION

The findings of two consecutive years showed that management of whitefly successfully achieved through application of bio-rational compounds. It was noted that grain yield of blackgram was enhanced sharply and reducing pest population through the application of bio-rational compounds. Biopesticide, microbial toxin spinosad showed highest efficacy against *B. tabaci* in reducing pest population and increasing grain yield. Cumulative mean efficacy on population reduction over control, after third insecticidal spray indicated that spinosad (tracer) @0.25 ml/l of water and imidacloprid (admire) @ 0.25g/l of water were highly effective. Thus application of spinosad @ 0.25 ml/lt or of water thrice at an interval of 10 days after 15 days of sowing in the field with respect to whitefly control and yield increment of blackgram.

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