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ORIGINAL ARTICLE

Comparative Efficacy of Bio-Pesticide and Synthetic Agrochemicals on Control of *Helicoverpa armigera* Larvae on Chickpea

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ABSTRACT

The comparative efficacy of neem as bio-pesticides and synthetic agrochemicals against the larvae of *Helicoverpa armigera* was carried out during 2016-2017. The experiment was performed using RCBD and consisted of a total of six treatments including the control with four replicates. The results indicated that the synthetic insecticide emamectin was found to be superior in controlling the larval population of pod borer with a % reduction of 63 and 88 after 1st and 2nd application respectively followed by chlorpyrifos after 2nd application. The neem bio-pesticide showed best results next to emamectin after the first application. The acetamiprid was found to be least effective in controlling the pod borer larvae.

Keywords

Bio-pesticide, pod borer, neem oil, chickpea, adjuvant.

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INTRODUCTION

The chickpea is attacked by *Helicoverpa armigera* which is commonly known as gram pod borer and is the main pest of the chickpea^{1,2}. This pest causes a great loss in chickpea³. In most of the chickpea producing area, the gram pod borer has been reported to have developed resistance to most of the commonly used pesticides⁴. The *Helicoverpa armigera* is a polyphagous insect and attacks more than 200 species of almost 45 crops throughout the world⁵. The total annual yield loss of different crops by *Helicoverpa armigera* has been reported to be a worth of 2 billion US dollars⁶.

The initial stage of the life cycle, larval stage control is important to prevent the severe damage and yield loss^{7,8}. Various control measures have been adopted to control or minimize the attack of chickpea pod borer⁹. Synthetic

pesticides are commonly used to control the pests. But the extensive use of synthetic pesticides has created several problems including mammalian toxicity, destruction of useful insects, resistance development in pests etc.¹⁰. Plant extracts are suitable and safe alternatives to toxic synthetic pesticides. The neem oil is obtained from *Azadirachta Indica* and possesses insecticide activities against a wide range of insect pests¹¹⁻¹³. The active ingredient in the neem oil is *Azadirachtin*. The neem oil is target specific and insects cannot develop resistance to it. The neem oil is not soluble in water and should be emulsified first before use. Usually, surf or detergents are used to emulsify the neem oil. This surf contains synthetic chemicals which may alter the chemistry of plants. Furthermore, the emulsified oil is made only when needed and cannot be stored for a long

time. We have developed an adjuvant at the Nuclear Institute for Food and Agriculture NIFA, Peshawar. This adjuvant is designated as NIFA-1 and acts as emulsifier, spreader, and sticker. We have observed that the neem oil emulsified with NIFA-1 adjuvant has shown pesticide activity after two years of storage. The total cost for the production of this adjuvant in Rs.200 per liter.

MATERIAL AND METHOD

Experimental Design

The experiment was carried out on chickpea variety NIFA-2005 during 2016-2017. The field was ploughed twice for seed sowing and the weeds and other grasses were also removed from the soil. The plot was divided into twenty-four 24 subplots. The space between the rows was 38 cm and the distance between the plants was 10 cm. There were a total of six treatments including a control with four replications. Seven plants were randomly selected in each subplot for the observation of chickpea pod borer larvae. The design used in this experiment was RCBD. The experimental data were analyzed by statistics 8.1 software. The percent data were subjected to square root transformation for statistical analysis. Mean comparisons for treatment parameters were compared using Tukey's tests at 5% level of significance.

Application of Insecticides

The pesticides were applied as a foliar spray with the help of knap sprayer. There were two sprays for each insecticide. The first application was done after the appearance of pod borer larvae and the second was done after one week of the first application. The treatments are shown in the following Table 1.

Table 1: Treatments of insecticides and concentration of dose.

Treatments	Pesticides	The Concentration of Dose (%)
T1	Emamectin benzoate	0.5
T2	Acetamiprid	0.5
T3	Chlorpyrifos	0.5
T4	Bifenthrin+neem oil+N.A	1
T5	Neem oil+N.A	3
T6	Control	----

Data Collection

The data was collected regarding the larvae of the pod borer. The data was taken by visual count method of the chickpea pod borer. The pretreatment record of the pod borer was noted 24 hours before the treatment and the post-treatment data was taken after one, two and three days of the applications. Seven plants per subplot were selected randomly for the observation of larvae of pod borer. Three distinct stages of the pod borer i.e. neonate, the middle and the fully grown larvae were noted. The percent reduction of larvae was determined by using Abbot Formula developed in 1925. The formula is written as;

% Reduction = $C-T/C \times 100$. Where,

C = larvae population in control

T = larvae population in treatment

The percent pod damage and the percent damage reduction of pod over control are given below¹⁴.

$$\% \text{ Pod damage} = \frac{\text{No. of affected pods}}{\text{Total no. of pods}} \times 100$$

$$\% \text{ reduction in pod damage Over control} = \frac{\text{Pod damage in control} - \text{Pod damage in treatment}}{\text{Pod damage in control}} \times 100$$

The biomass containing the dry chickpea plant was calculated by weighing the chickpea plant at harvest.

RESULTS & DISCUSSIONS

First Application of Pesticides

The data in Table 2 shows the pretreatment and post-treatment larval population of the chickpea pod borer for the first application of the pesticides. It can be seen from the pretreatment data that chickpea plants contain a large number of the pod borer larvae of neonate stage which is the first distinct stage of the pod borer. There was almost the same population of the neonates before treatments in all the subplots. The number of neonates in the case of emamectin and Acetamiprid was 6.2 and 5.8 respectively. The number of neonates was 7.2 and 7.1 in case of chlorpyrifos and bifenthrin +emulsified neem oil combination respectively while the emulsified neem oil and control has a population of 6.5 and 6.8 respectively. The middle stage larval population was 0.3 for emamectin and 0.2 each for chlorpyrifos and neem oil treatment,

while this middle instar was absent in case of acetamiprid, bifenthrin +emulsified neem oil combination and control treatments respectively.

combinations treatment which consists of neem oil and NIFA adjuvant and bifenthrin as a synergist. The last treatment which consists of purely neem oil and NIFA

Table 2: Pretreatment and post-treatment larval population of pod borer after 1st spray.

S. No	Larval population (Pretreatment)					Larval population (Post-treatment)				
	Treatments	N	M	F	Total	Mean	N	M	F	Total
T1	6.2±1.6a	0.3±0.21a	0±0	6.5	2.1	5.2±1.8bc	0.5±0.3c	0.1±0.1b	5.8	1.93
T2	5.8±0.9a	0±0b	0±0	5.8	1.93	7.6±1.2ab	0.6±0.4c	0.8±0.3a	9	3
T3	7.2±1.6a	0.2±0.18ab	0±0	7.4	2.4	5.1±0.98bc	1.6±0.47bc	0.1±0.08b	6.8	2.2
T4	7.1±1.6a	0±0b	0±0	7.1	2.3	3.2±0.8c	2.7±0.6b	0.2±0.2b	6.1	2.03
T5	6.5±0.9a	0.2±0.14ab	0±0	6.7	2.2	3.4±0.6c	2.7±0.4b	0±0b	6.1	2.03
T6	6.8±1.1a	0±0b	0±0	6.8	2.2	9.11±1.7a	5.3±0.9a	1.2±0.3a	15.6	5.2

Where, N= neonate, M=middle and F=fully grown larval stages respectively

The fully grown instar of the larvae was absent in all the subplots before the application of the 1st spray. So the pretreatment total larval population of all the three instars of the pod borer larvae in case of emamectin and acetamiprid was 6.5 and 5.8 respectively while chlorpyrifos and bifenthrin +emulsified neem oil combinations have total larval population 7.4 and 7.1 respectively. Total larval population in case of emulsified neem oil and control treatments were 6.7 and 6.8 respectively. The mean value of the three instars of the chickpea pod borer larvae before the treatment were 2.1, 1.93, 2.4, 2.3, 2.2 and 2.2 for emamactin, acetamiprid, chlorpyrifos, bifenthrin + emulsified neem oil combination, emulsified neem oil and control treatments respectively. The post-treatment data shows that emamectin, the treated plot has a neonate instar population of 5.2 per seven plants while the middle instar (M) has a population of 0.5 and 0.1 fully grown instar. The acetamiprid treated plot has neonate instar population of 7.6 per seven plants. In this treatment, the number of middle instar population was 0.6, while the fully mature instar (F) population was 0.8. The chlorpyrifos treated plot has a post-treatment neonate population of 5.1 per seven plants. In this treatment, the middle instar (M) has a population of 1.6 and 0.8 population of fully mature (F) instar. The bifenthrin + emulsified neem oil combination treatment has a decline in the neonate instar population with a value of 3.2 per seven plants. The middle instar, (M) and the fully grown instar (F) population were found to be 2.7 and 0.2 respectively in case of bifenthrin +emulsified neem oil

adjuvant as emulsifier has a neonate population of 3.4, while the middle instar larval population was found to be 2.7 and no population of the fully grown instar larva was found. The population of neonates were increased in the case of control and was 9.1 per seven plants. The middle instar of larva was also present in large number as compared to all other treatments and their population was 5.3. Similarly, the full-grown larval instar (F) population was recorded to be 1.2. It can be seen from Table 2. that total larval population in case of emamactin, acetamiprid, chlorpyrifos, bifenthrin + emulsified neem oil combination, emulsified neem oil and control treatments were 5.8, 9, 6.8, 6.1, 6.1 and 15.6 respectively while the mean values of all the three larval populations were 1.93, 3, 2.2, 2.03, 2.03 and 5.2 respectively.

Second Application of Pesticides

The second application of the pesticides was performed after one week of the first application. In this case, the pretreatment data of the chickpea pod borer was also noted one day before the application of the spray and the post-treatment data was taken after one, two and three days of the application. The pretreatment data shows that the number of neonate population was considerably low and was 0.9 in case of ememactin, the middle instar (M) has a population of 0.2 per seven plants while the fully grown instar (F) was still not found. It can be seen from Table 3 that acetamiprid treatment has a neonate instar population of 0.7 and middle instar pod borer population of 0.6 and a fully grown larval population (F) with a value of 0.2. chlorpyrifos treatment has a neonate population of

1.6, middle (M) instar population of 0.7 and the fully grown larval population of 0.1 respectively. The neonates, middle and the fully grown pod borer larvae population values were 0.6, 1.4 and 0.3 respectively for bifenthrin + emulsified neem oil combination treatment. The neem oil emulsified with NIFA adjuvant has a neonate population of 0.8, middle (M) stage larval population of 0.7 and 0.1 population of fully mature instar larva of pod borer. In the case of control, the neonate instar population was 1.4, middle instar population (M) was 1.7 while the fully grown instar has a population of 0.6. The pretreatment total larval populations for emamectin, acetamiprid, chlorpyrifos, bifenthrin + emulsified neem oil combination, emulsified neem oil and control were 1.1, 1.5, 2.8, 2.3, 1.6 and 3.7 respectively and the mean values of this larval instar were 0.36, 0.5, 0.9, 0.76, 0.53 and 1.23 respectively.

mean was 2.96 for acetamiprid. The chlorpyrifos treated plants have a neonate instar population of 0.2 after the application of the 2nd spray. The middle larval stage population has a value of 3.5 and the fully grown larva was found to be 0.5 per seven plants for the post-treatment of the 2nd application. In this case, the total larval population was 4.2 and the mean population of all the three instars was 1.4. The bifenthrin + emulsified neem oil combination treatment consisting of neem oil, NIFA adjuvant and bifenthrin as synergist has total neonate post-treatment population of 2.1, and middle and fully grown instar population of 4.2 and 1 respectively. The total larval count for this treatment was 7.3 and the mean value of all the instars was 2.4. The neem bio-pesticide which was emulsified neem oil treatment has the neonate population of 2.3, middle and fully grown instars population of 3.2 and 0.4 respectively. The total and

Table 3: Pretreatment and post-treatment larval population of pod borer after 2nd spray.

S. No	Larval Population (Pretreatment)				Larval Population (Post-Treatment)					
	Treatments	N	M	F	Total	Mean	N	M	F	Total
T1	0.9±0.36ab	0.2±0.18c	0±0b	1.1	0.36	0.4±0.2c	2.7±0.37c	0.6±0.35b	3.7	1.23
T2	0.7±0.3b	0.6±0.34c	0.2±0.18ab	1.5	0.5	3±0.6b	4.9±0.7b	1±0.7b	8.9	2.96
T3	1.6±0.6a	0.7±0.37bc	0.1±0.14b	2.8	0.9	0.2±0.1c	3.5±0.6bc	0.5±0.18b	4.2	1.4
T4	0.6±0.26b	1.4±0.31ab	0.3±0.16ab	2.3	0.76	2.1±0.33bc	4.2±0.31bc	1±0.62b	7.3	2.4
T5	0.8±0.29ab	0.7±0.28bc	0.1±0.1b	1.6	0.53	2.3±0.46bc	3.2±0.38bc	0.4±0.24b	5.9	1.96
T6	1.4±0.4ab	1.7±0.29a	0.6±0.3a	3.7	1.23	11.5±2.6a	15.5±1.6a	5.1±1.4a	32.1	10.7

Where, N= neonate, M=middle and F=fully grown larval stages respectively

The post-treatment larval population data was conducted after one, two and three days of the application. It can be seen from the Table 3 that emamectin treatment has a low population of neonate instar and has a value of 0.4, and the population of the middle (M) instar was 2.7 per seven plants while the fully grown larvae have a population density of 0.6. So the total larval population of all the instars of the pod borer was 3.7 and their mean was 1.23 after the application of the 2nd spray. The acetamiprid treated plot has a greater population of the neonate larvae than that of emamectin and has a value of 3 and the middle instar population of 4.9 and the fully mature larval population of 1 respectively. It can be seen from Table 3 that total post-treatment larval population for all the three instars of the pod borer was 8.9 and the

mean larval population values for this treatments were 5.9 and 1.96 respectively. The largest population of neonates was 11.5 in case of control group while the middle (M) and full grown instars have the population of 15.5 and 5.1 respectively. The total larval population for emamectin, acetamiprid, chlorpyrifos, bifenthrin + emulsified neem oil combination, emulsified neem oil and control were 3.7, 8.9, 4.2, 7.3, 5.9 and 32.1 respectively and their mean was 1.23, 2.96, 1.4, 2.4, 1.96 and 10.7 respectively.

The results obtained after the application of pesticides show that all the pesticide treatments have a greater effect on the control of larvae of the chickpea pod borer than the control. All the six treatments have almost the same number of larval instar before the treatment of the first spray. The first larval population was observed in the

first week of April. The neonate, which is the first instar was present in all the observed subplots, and the middle instar which is formed by the conversion of neonate instar was observed only in the bifenthrin + emulsified neem oil combination and control treatments before the application and has a value of 0.2 each for both the treatments. The fully grown instar (F) was absent in all the pretreatments plots. After the application of the pesticides, it was found that emamactin has the highest effect on the control of the chickpea pod borer larvae. % reduction in the larval population was 63 after the first spray. bifenthrin + emulsified neem oil combination and emulsified neem oil treatments have an almost the same effect on the control of pod borer larvae and % reduction in case of this two treatment was 60 in each. The chlorpyrifos has the larval % reduction of 56.4 while acetamiprid was the least effective treatment for the control of pod borer larvae after the application of the first spray. The % reduction in the larval population was more pronounced after the application of the 2nd spray. Table 4 shows that emamactin has the lowest control of pod borer larvae and the % reduction in the larvae was 88. The chlorpyrifos showed the second best results after emamactin and the % reduction in the larval population, in this case, was reported to be 86.9. The bio-pesticide showed 81 % reduction in the larval population of pod borer. The bifenthrin + emulsified neem oil combination treatment which was almost the same as that of emulsified neem oil treatment after 1st spray showed a decreased efficacy as compared to emulsified neem oil treatment in lowering the larval population and showed a % reduction of 77. Acetamiprid was the least effective in controlling the larval population after the 2nd spray and the total % reduction was noted to be 72.

Table 4: Percent reduction of the chickpea pod borer larvae after each spray.

Treatments	% Reduction (1 st spray)	% Reduction (2 nd spray)
T1	63	88
T2	42.3	72
T3	56.4	86.9
T4	60	77
T5	60	81
T6	—	—

Percent Pod Damage and Pod Damage Reduction

The percent damage of pod for each treatment is shown in Table 5. The highest pod damage was observed in control, while the lowest value was observed in case of emamactin with a pod damage % age of 13.33 the chlorpyrifos treatment showed a pod damage of 14 percent while the emulsified neem oil has a percent reduction of 14.66. In the case of pesticide treatments, acetamiprid has the highest pod damage after the control and the percent pod damage reported was 17.33 percent. Similarly, the highest pod damage reduction over control was also noted in the case of emamactin application and the lowest value was observed in the case of acetamiprid having values of 44.4 % and 27.7 percent. The neem oil has 38.8 % damage reduction while bifenthrin + emulsified neem oil combination has a % age damage pod reduction of 30.5.

Table 5: Percent pod damage and percent reduction of pod damage over control.

Treatments	% Damage pod	% Reduction in pod Damage over control
T1	13.33b	44.4
T2	17.33ab	27.7
T3	14b	41.66
T4	16.66ab	30.5
T5	14.66b	38.8
T6	24a	—

Grain Yield

The grain yield obtained after the harvest of the chickpea plant are shown in Table 6. The highest grain yield was obtained for emamactin and the percent increase over the control was recorded to be 47.8 percent. The emulsified neem oil treatment yield was second after emamactin and was 22.5 kg and the percent increase was noted to be 40.6. The yield of grain was recorded for control and was 16 kg only. Suneel Kumar used emamactin against the chickpea pod borer and found that emamactin has 83.7 % control over the control. Patel *et al.* found that emamectin showed a better activity against the chickpea pod borer¹⁵ and Singh and Yadav found the lowest pod damage 12.5 percent in chickpea in case of indoxacarb¹⁶. Jawad *et al.* observed that neem oil possessed almost the same

Table 6: Bio-mass and grain yield of chickpea for all treatments.

Treatments	Bio-mass (kg)	Grain Yield (kg)	% increase in grain over control
T1	90.5a	23.66a	47.8
T2	79c	19.7ab	23
T3	81.5bc	20.33a	27
T4	85abc	21.8a	36.2
T5	88ab	22.5a	40.6
T6	67d	16b	

activity against the *H. armigera* on tomato vegetables¹⁷. They noticed that mean larval of pod borer per plant were 0.40 and 0.46 for neem and emamectin treatments respectively. Rajput *et al.* reported that synthetic insecticide was found to be the best treatment as compared to natural products¹⁸. Gohokar *et al.* found that neem treatments gave best results than synthetic insecticides¹⁹. Gilani noted that neem oil possesses repellent, insecticide and anti-feeding characteristics²⁰. Singh and Kumar reported that emamectin was the effective insecticide in lowering the population of *H. armigera* in chickpea²¹. Sontakke *et al.* found that emamectin benzoate was found effective in decreasing the population of fruit borer and fruit damage in okra as well as tomato crops²². Neem oil showed a tremendous antifeedant, insecticidal and insect growth regulatory properties²³. In one study, it was found that Bollcure fraction and NSKE was highly effective and economical in lowering the *H. armigera* larvae in chickpea²⁴.

CONCLUSIONS

The bio-pesticide of neem oil showed better results in controlling the pod borer larval population next to chlorpyrifos and emamectin after the 2nd spray. The highest grain yield was reported for emamactin followed by emulsified neem oil treatment. Pakistan is the 3rd largest producer of chickpea and there is need to use the bio-pesticide due to WTO constraints for the export-oriented agro-product and neem oil has proved to be a good bio-pesticide. This product is purely organic and a prominent candidate as a pesticide in organic farming. This product has been used effectively in controlling the aphid and potato leafhopper control. Further study is

recommended on further crops and a pest to study the effect of the biopesticide.

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