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Economic analysis of mustard aphid management on rapeseed in Chitwan district of Nepal

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Abstract
The economic analysis of mustard aphid management on rapeseed in Chitwan district is insufficient. So, an experiment was conducted to monitor aphid population and to evaluate the economic constraints of *Lipaphis erysimi* (Kalt.) on rapeseed from November 2017 to February 2018. The experiment was laid out in split plot design with three replications. The three varieties (Pragati, Bikash and Unnati) of mustard is main factor and insecticidal treatment were sub factor of experiment which include i) Spinosad 45% suspension concentrates at 0.44 ml/lit of water, ii) Imidacloprid 70 water dispersible granule at 0.14 gm/ lit of water, iii) *Beauveria bassiana* 1.15% wettable powder at 2g/lit of water, and iv) Untreated control. The yield, biomass and Harvest Index was statistically similar among all varieties. Seeds per pod, yield, biomass, and Harvest Index was the highest with Imidacloprid followed by Beauveria, Spinosad and Control. Cost of production, net return, gross return, and B:C ratio was found maximum in Imidacloprid compared with other treatments. The highest number of aphid population was seen during the last week of December to mid-January in Chitwan. Imidacloprid was found the most effective and economically viable option for aphid management which could be a potential measure for the economic management of aphid in rapeseed in the district.

Keywords: Aphid, biomass, economic, rapeseed

Introduction

Oilseed crops have been grown all over the world and are considered important crops due to their economic value. Oilseed crops are primarily grown for edible oil. Oil from the seeds of plants belonging to the genus *Brassica,* family Cruciferae, have been utilized by man for thousands of years (Prakash & Hinata, 1980) [15], but it is only during the last 30 years that oilseed crops have become internationally important (Lamb, 1989) [14]. Rapeseed and mustard are the third most important edible oilseed crops of the world after soybean and oil palm.

Rapessed crop suffer heavy loss in yield due to various biotic and abiotic factors. The native bollworm, *Helicoverpa punctigera* (Wallen); chinch bug, *Nysius vinitor* (Dallas); cabbage aphid, *Brevicoryne brassicae* (L.); mustard aphid, *Lipaphis erysimi* (Kalt.) and the green peach aphid, *Myzus persicae* (Sulzer) are irregular and unpredictable pests at the flowering and pod formation stage of rapeseed plants (Hainan, 2007) [9]. In India among 38 attacking rapeseed species, mustard aphid, *Lipaphis erysimi* (Kalt.), mustard painted bug, *Bagrada cruciferarum* (kirki); leaf miner, *Chromatomyia horticola* (Goreau) and hairy caterpillar were seen infecting the crop (Aicorpo, 1987) [1]. In Nepal common insect pest infecting rapeseed crop are Mustard sawfly, *Athalia lugens* (Proxima); Plant hopper, *Kelisia fieberi* (Muir); Mustard aphid, *Lipaphis erysimi* (kalt.) (Joshi & Manandhar, 2001) [10].

In recent years, organic pest control agents have been proved successful for pest management strategy. Arancon *et al*. (2007) [2] tested the capability of vermi-composts, formed commercially from food wastes, to restrain populations and injure to plants, by two-spotted spider mites (*Tetranychus urticae Koch*), mealy bugs (*Pseudococcus sp.)* and aphid (*M. persicae*). Almost all of the mixtures concealed the arthropod pest populations and reduced pest injure considerably in comparison to the untreated controls.

However, some chemicals have posed some serious problems to health and environmental safety, because of their high toxicity and prolonged persistence. Thus, newer approaches for pest control are continuously being sought. The naturally occurring, biologically active plants appear to have a prominent role for the development of future commercial pesticides not only for increased productivity & profit but for the safety of the environment and public health. Good control of mustard aphid can be obtained by spraying traditional organic insecticides (Bakhetia, 1984; Khurana *et al.*, 1989) [3, 12].

Botanicals are, in general, more compatible with the environmental components than the synthetic pesticides, owing primarily to their susceptibility to degradation by light, heat and microorganism. Mycopesticides have lowered or eliminated resistance problem (G.C, 2006) in the meantime, there is no report of pest resurgence due to the use of botanicals. The overuse of chemicals has resulted in the pollution of environment, losses to farmers due to increase in cost of production and ecosystem instability in Chitwan district. In this study, different varieties of rapeseed were screened and entomopathogenic fungi and chemical insecticides were assessed to identify the economically best varieties against mustard aphid in rapeseed.

Objective

To study the economics of rapeseed crop caused by the infestation of mustard aphid, *Lipaphis erysimi (*Kalt.) in different varieties under field condition.

Materials and Methods

Monitoring and management of Mustard aphid in rapeseed, *Lipaphis erysimi* (Kalt.) utilizing entomopathogenic fungus, microbial insecticide and chemical insecticide were the two aspects of study which were carried out during Winter Season from November 2017 to February 2018 in Chitwan district of Nepal.

Monitoring

The appearance and dispersal of winged aphids, i.e., alate *Lipaphis erysimi* (Kalt.) in rapeseed crop were studied in one crop season. Three yellow sticky traps of size 60*15 cm and with sticky surface in only one side was installed at 1m height from the ground around each replication. Average number of aphids catches on yellow sticky traps were recorded in each week and traps were also changed at weekly interval. The trap was installed from 3 December 2017 to 11 February 2018.

Field experiment

The field experiment was conducted to test the economic efficacy of entomopathogenic fungus, commercial insecticides, and control (unsprayed) against mustard aphid in three varieties of rapeseed under field condition in Chitwan district of Nepal from November 2017 to February 2018.

Description of the experimental site

Location

The experiment was conducted at Agronomy Farm, AFU, Rampur, Chitwan. Geographically it is located at $27^0$37' N latitude 84^0 25' E longitude and at an altitude of 256 meter above sea level. According to the geographical classification of the country, the experimental location falls in the Terai region of Central Development Region.

Agro-meteorological information

The climate of the experimental site is sub-tropical (November 2017 to February 2018).

Cropping history

The Agronomy field of Agriculture and Forestry University, Rampur was the experimental field. Different entomological and pathological research were conducted during the course of time, but the field was cultivated with rice before cropping of rapeseed. Field was barren for about three months prior to rapeseed cultivation.

Details of the experiment

The experiment was carried in split plot design. Main plot factor was Variety and sub-plot factor was insecticide for the experiment. Similarly, a commercial entomopathogenic fungus (Beauveria), two chemical insecticides (Spinosad and Imidacloprid) and control (water spraying) were used as insecticidal sprays. Pragati, Bikash and Unnati are the three varieties used for the study (Table 1). The individual plot size was 2.4m×2.1m (5.04m^2) and sown with 30cm apart each row. The plant-to-plant distance was maintained at 5cm. The space between two blocks was 1m and the space between two plots was 0.5m. Each plot consisted of 8 rows of 2.1 m length, where middle 6 rows were considered for yield evaluation.

Details of Treatments

Table 1: Details of treatment

S. N.	Common name	Trade name	Dose
1	Spinosad 45% SC	Tracer	0.4 ml/ lit of water
2	Imidacloprid 70WSG	Admire	0.14gm/lit of water
3	Beauveria 1.15% WP	Racer	2gm/lit of water
4	Control (water spraying)		
	Variety		
6	Pragati		
7	Bikash		
8	Unnati		

Treatment combination

T_1: Spinosad + Pragati
T_2: Imidacloprid + Pragati
T_3: *Beauvaria bassiana* + Pragati
T_4: Control + Pragati
T_5: Spinosad + Bikash
T_6: Imidacloprid + Bikash
T_7: *Beauvaria bassiana* + Bikash
T_8: Control + Bikash
T_9: Spinosad + Unnati
T_{10}: Imidacloprid + Unnati
T_{11}: *Beauvaria bassiana* + Unnati
T_{12}: Control + Unnati

Preparation of insecticide sprays

In case of liquid insecticides, the required quantity of insecticide was added to little quantity of water and stirred thoroughly and then remaining quantity of water was poured to get the required concentration of final spray. In case of dust insecticide, required amount was weighed and mixed with little quantity of water and remaining quantity of water was added with continuously stirring. The amount of insecticide required per liter of water was calculated by the formula given below:

Insecticide per liter of water= Concentration required/ percent a.i. ×100

Method and time of application

Altogether three sprays were done in all the treatments. The first spray started 40 days after sowing when population of aphids started appearing and repeated at 12 days interval. A knapsack sprayer was used for spraying and cleanliness of sprayer was carried out after each spray of insecticide.

Maximum care was taken to cover the whole plant surface with the spray materials. Spraying was carried out at evening time.

Cultural practices
Land preparation
The field was ploughed three times to bring the soil under good tilth and planking was done after each ploughing for leveling the land. After leveling, the clods were broken, and weeds and stubbles were removed.

Manure and fertilizer application
The recommended amount of FYM (12mt/ha) was weighed and broadcasted uniformly in the experimental field after first plowing and mixed well in the soil. The required quantity of fertilizers was applied in the individual plot after final land preparation, i.e., NPK @ 60:40:20 kg/ha, respectively as basal dose. Nitrogen and Phosphorus were applied through DAP (Diammonium Phosphate) containing 18%N and 46% P_2O_5. Remaining dose of nitrogen was applied through urea containing 46% N and potash through Muriate of Potash (MOP) containing 60% K_2O.

Seed rate and sowing
6 kg/ha was seed rate used for sowing. The required amounts of seed for each individual plot were calculated. Further it was divided into 9 equal parts and each part was sown in line continuously by opening a small furrow at a depth of 2-3 cm. After this, the furrow was covered with thin layer of soil. Sowing was done in November 23th, 2017.

Weeding and thinning
Hand weeding and thinning were done 15 days after sowing. After that two successive thinning and hand weeding were performed at weekly intervals. Final plant stands 67 plants/m^2 was maintained on 30 days after sowing. First weeding was done on 8th December 2017.

Harvesting
Harvesting was done by cutting the whole plants with sickle from soil surface. The net harvesting area was 5.04m^2. Harvested plants were sun dried in the field and brought to threshing floor by making bundles of each plot separately. Threshing of the crop for each plot was done separately and carefully.

Observation and measurement
Aphid population
Observations of the aphids were carried from 10cm apical central shoot of inflorescence from 15 randomly selected and tagged sample plants of each plot. Both pre-treatment and post-treatment observations were taken for mustard aphid. Record of post-treatment was done after 4, 8 and 12 days of spray and pre-treatment observation was carried on 24 hours before first spray, whereas in case of second and third spray, count taken at 4, 8 and 12 days after each spray.

Yield and yield attributes
Test weight
Thousand seeds were taken from the harvested seed lot randomly and their weight were calculated separately to find out test weight and expressed in gram.

Seed yield: Seed yield was taken from the net harvested area from each plot. After drying, the plants were threshed to separate the seeds. Seeds were cleaned properly, dried at 8% moisture content, and weighed for each plot separately. Then the yield was converted into kg/ha.

Biomass
Biomass was taken from whole plot. After seeds were threshed from the pod's biomass was weighed by weighing machine.

Economic analysis
Cost of various cultural practices was worked out and gross income was calculated on the basis of prevailing market price of the products. Benefit-cost ratio was calculated by dividing the gross return with the cost of cultivation.

Statistical analysis
The recorded data were all tabulated and systematically arranged treatment wise under three replications using Ms-Excel which were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT-0.05 level) for mean separations using Gen stat software (Gomez & Gomez, 1984) [7].

Results
Economic Analysis
Cost of cultivation
The total cost of production included all general and treatment wise variable cost. Insecticides and seeds of the varieties were the variable costs and other costs were included as general. The mean production cost in this experiment was NRs. 21881 ha^{-1}. The highest production cost occurred in variety Pragati (NRs. 21966 ha^{-1}) followed by Bikash (NRs. 21874 ha^{-1}) and Unnati (NRs. 21802 ha^{-1}). Similarly, the highest production cost occurred in insecticide Imidacloprid (NRs. 22031 ha^{-1}) followed by Beauveria (NRs. 21908 ha^{-1}), Spinosad (NRs. 21889 ha^{-1}) and Control (NRs. 21695 ha^{-1}) (Table 9).

Gross return
The mean gross return of NRs. 48152 ha^{-1} was obtained, and higher gross return was attained in Bikash (NRs. 51442 ha^{-1}) which was higher than the other two varieties. This was followed by Pragati (NRs. 46955 ha^{-1}) and Unnati (NRs. 46058 ha^{-1}) which were both at par.
Similarly, higher gross return was obtained in the Imidacloprid used than other insecticides and control. Gross returns with Imidacloprid were higher (NRs. 72059 ha^{-1}) than all other treatments which was followed by Beauveria (NRs. 45537 ha^{-1}) (Table 9).

Net return
Net return varied non-significant among the varieties and significantly influenced by insecticide applications. The mean net return was NRs. 26271 ha^{-1} in this experiment. Higher net return was obtained in Bikash (NRs. 29568 ha^{-1}) which was higher than the other two varieties.
Similarly, higher net return was obtained in the Imidacloprid than other insecticides used and control. Net returns from 160 kg N ha-1 were higher in Imidacloprid (NRs. 50028 ha^{-1}) than all other treatments (Table 9).

B:C ratio
Among the varieties, higher B:C ratio was obtained in

Bikash (2.36). This was followed by Pragati (2.14) and Unnati (2.11).

B:C ratio was higher with Imidacloprid (3.28) followed by *Beauveria basiana* with B:C ratio (2.08). The B:C ratio was 1.78 with Spinosad and only 1.67from Control plot (Table 2).

Table 2: Benefit-cost ratio of different treatments for the management of aphid, *Lipaphis erysimi* (Kalt.) attacking rapeseed (November 2017-Februray, 2018)

Treatment				
Factor A (Variety)	**Cost of cultivation**	**Gross return**	**Net Return**	**B:C ratio**
Pragati	21966	46955	24989	2.14
Bikash	21874	51442	29568	2.36
Unnati	21802	46058	24256	2.11
Factor B (insecticide)				
Spinosad 25% EC @ 0.44 ml/lit of water	21889	38879	16990	1.78
Imidacloprid 0.5% SC @ 0.14gm/lit of water	22031	72059	50028	3.28
Beauvaria basiana 1.15% WP @ 2 gm/lit of water	21908	45537	23629	2.08
Control	21695	36132	14437	1.67

Discussion

Higher production cost occurred in insecticide Imidacloprid (NRs. 22031 ha^{-1}) and least by Control (NRs. 21695 ha^{-1}). Similarly, higher net return was obtained in the Imidacloprid than other insecticides used and control. Higher gross return was obtained in the Imidacloprid used than other insecticides and control and net returns from 160 kg N ha^{-1} were higher in Imidacloprid (NRs. 50028 ha^{-1}) than all other treatments. B:C ratio was higher with Imidacloprid (3.28) followed by *Beauveria bassiana* with B:C ratio (2.08). The B:C ratio was 1.78 with Spinosad and only 1.67 from Control plot.

Devee *et al.*, (2011) [4] and Singh *et al.*, (2014) [17] reported that Imidacloprid found superior in reducing aphid population than other insecticides. Ghosal *et al.*, (2013) [6] and Konar *et al.*, (2013) [13] also reported that imidacloprid as the best insecticides in reducing aphid population. Many other researchers support the findings incurred in this research.

With regard to insecticidal application the highest net gain (Rs. 28557 ha-1) as well as incremental cost-benefit ratio (1:14.62) were obtained with imidacloprid which was followed by other treatments (Konar *et al.*, 2013) [13]. Gour & Pareek (2003) [8] and Reza *et al.*, (2004) stated that higher cost-benefit ratio with Imidacloprid treatment in comparison to other insecticides. Konar *et al.* (2013) [13] identified imidacloprid as the most economical insecticides with maximum incremental cost benefit ratio with high cost of treatment. These findings are in confirmation with our result that cost of cultivation, Net return, and B:C ratio were higher in case of Imidacloprid spray in comparison to other treatments.

Conclusion

Aphid is one of the most damaging insect pests of rapeseed. Monitoring and management of Mustard aphid in rapeseed, *Lipaphis erysimi* (Kalt.) utilizing entomopathogenic fungus, microbial insecticide and chemical insecticide were the two attributes of study which were carried out during Winter Season from November 2017 to February 2018 in Chitwan district of Nepal. The highest number of aphid population was seen during the last week of December to mid-January in Chitwan district. Cost of production, net return, gross return, and B:C ratio was found maximum in Imidacloprid compared with other treatments. Imidacloprid was found the most effective and economically viable option for aphid management which could be a potential measure for management of aphid in rapeseed.

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