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Relative efficacy of various insecticides against alfalfa weevil, *Hypera postica* G. (Coleoptera: Curculionidae) on lucerne (*Medicago sativa* L.) crop and elaboration of hazardous effects on predators

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Abstract
The studies were conducted to determine the efficacy of seven insecticides viz., spinosad (Spintor 480SC)@ 100 ml, chlorantraniliprole (Coragen 20SC) @ 62.5 ml, lufenuron (Marshal 5EC) @ 500 ml, methoxyfenozide (Runner280SC) @ 250, emamectin benzoate (Emamectin1.9 EC) @ 500 ml, bifenthrin (Welthrin 10EC) @ 500 ml, flubendamide (Belt 48SC) @ 125ml per hectarewith different mode of actions were tested against alfalfa weevil (*Hypera postica* G.) in the field of lucerne crop at Fodder Research Institute, Sargodha during, 2016-17. The data was recorded pre and post (3, 5, 7 and 10 days) treatment. Results showed that all seven insecticides gave satisfactory results as compared with control. But statistically highest mortality was found with the application of spinosad, emamectin benzoate and bifenthrin while the lowest mortality was found with chlorantraniliprole, methoxyfenozide, lufenuron and flubendamide. Biopesticides, **e**mamectin benzoate, spinosad were remained comparatively safe for predators as compared with pyrethroids bifenthrin.

Keywords: Alfalfa weevil, major pest, insecticides, predator, population, alfalfa variety SGD-2002, Pakistan

1. Introduction
Alfalfa (*Medicago sativa* L.) known as lucerne is highly valued legume forage crop and perennial in nature which may provide green fodder continuously for 3-4 years from the same sowing. It is loved by all kinds of livestock due to its nutritious and palatable quality possesses about 16-25% crude protein and 20-30% fiber [1]. It is not only important forage crop but also improve soil fertility through the addition of biologically fixed nitrogen [2]. In Pakistan lucerne is mainly grown for the purpose of green fodder and seed production. There are so many uses of lucerne. For example it contains great amount of protein and some kind of vitamin like "Vitamin-A", it is used as feed for fish and poultry industries. Due to its high profitable values, growers cultivate this crop for seed production as well as store it in the form of hay and silage which can be used at the time of need. But our lucerne production both for fodder and seed is low as compared with other countries of the world. There are so many reasons of low productions but insect pest are considered one the main reason which affects the profitability of alfalfa production. Among insect pests, alfalfa weevil, considered the most dangerous pest which skeletonizes leaves, leaving a whitish or frosted appearance across the field [3].Alfalfa weevil is reported as phytophagous pest [4] both adults and larvae damaged the stems and crown buds result in retarding regrowth [5] and their feeding reduces yield, quality, and stand health.
Several control measures are being adopted globally to overcome this pest like cultural, biological and chemical practices. Among other control measures resistant varieties are also considered better practices to overcome the pest, but presently available varieties do not provide sufficient protection from alfalfa weevil (AW larval) [4]. Cultural practice like early harvest of crop is considered as good practice which reduced AW larval numbers in post-harvest stubble by 43% [4]. Whereas some other scientist concluded that repeated early harvesting of regrowth typically has a negative impact on yield and stand longevity [6].

However, fall regrowth of alfalfa can be used as suitable pasture without negatively impacting harvest quantity or quality [7]. Grazing of animals is considered helpful in the management of AW. But Goosey [7, 8] reported that winter and spring sheep grazing reduced AW larvae 40-70%, whereas Schlegel [9] concluded that control of AW through grazing with sheep is not a common practice. So there is need of some alternate control measures. Among various component of IPM practices insecticides are considered as an integral component, which is not only the effective option available to producers to minimize economic losses.

Keeping in view the tarnished behavior of this pest, the present study was planned to evaluate the most suitable insecticides which are safer and most effective against Alfalfa weevil and as result save the crop from its damage. Screened best will be recommended for the maximization of green fodder, seed yield and quality. Further hazardous effects of these chemicals on predators will also be evaluated under field conditions.

2. Materials and Methods

Following insecticides viz., Spintor 480SC(spinosad) (Jaffar Brother) @ 100 ml, Coragen 20SC (chlorantraniliprole) (F.M.C) @ 62.5 ml, Marshal 5EC (lufenuron) (F.M.C) @ 500 ml,Runner280SC (methoxyfenozide) (Dow Agro Sciences) @ 250, Emamectin1.9 EC (emamectin benzoate) (R.B. Awari) @ 500 ml, Welthrin 10EC (bifenthrin) (Welcon) @ 500 ml, Belt 48SC(flubendamide) (Bayer) @ 125 dose per hectare were sprayed against grub of alfalfa weevil. The crop was sprayed with the help of hand knapsack sprayer on lucerne variety SGD-2002sown on01.12.2017.

2.1 Study area

The experiment was conducted at Fodder Research Institute, Sargodha during 2016-17. Sargodha is located Latitude and longitude coordinates are: 32.082466, 72.669128 and elevation is 189 meters height

2.2 Experimental layout

There were eight treatments including a control under Randomized Complete Block Design (RCBD) with three replications. The plot size for each treatment was 3 x 5m. There were six lines per plot with 45 cm apart. All the inputs applied were same in all the treatments.

2.3 Data recording

The population of grub of Alfalfa weevil was counted from 15 tillers selected at random from each treatment before spray and then after 3, 5, 7 and 10 days post treatment. After recording data the crop was sprayed. The spray was repeated after 15 days interval when again the maximum population of the grub of Alfalfa weevil per tiller developed. Calibration was done before spray for measuring the quantity of water used by each treatment.

Percent mortality was calculated by using the below mentioned formula:

$$\text{Percent mortality} = \frac{(\text{Population before spray} - \text{Population after spray})}{\text{Population before spray}} \times 100$$

2.4 Data on predator population

The population of available predators like coccinellids, rove beetles, syrphid flies,spider and chrysopa populations were counted from the treatments before andjust after 24 hours of spray. For counting predator's population a plastic sheet of 2x4 feet was spread between the lucerne rows. Ten plants were shaked on this plastic sheet. The whole materials were put in polythene bags. The collected materials were put in the refrigerator for 2-3 hours. After such period the samples were spread on white paper and population of predators were counted.

2.5 Statistical analysis

All the treatments were compared with control and one another to assess the performance of the treatment in uncontrolled field condition. The data were finally subjected to statistical analysis using Statistix version- 9 (www.statistix.com/free trial.html) and means were compared by Tukey's HSD.

3. Results

The mean values showing common letters do not differ significantly. In the year 2016-17, the data on percent mortality of alfalfa weevil grub after 1st spray were recorded and presented in Table.1 revealed highly significant differences between treatments. The result showed that the insecticides bifenthrin (82.60%) and emamectin (79.74%) caused more mortality of the pest followed by spinosad (75.69%). The minimum morality of the pest was recorded in lufenuron (37.92%) and runner (46.37%) three days after spray. Similarly after five days the highest mortality of the pest was recorded in emamectin (83.50%) and bifenthrin (78.21%) and lowest in lufenuron (25.84%). After seven days of spray, bifenthrin (72.26%), spinosad (67.23%) and emamectin (66.20%) gave highest mortality of the pest. Whereas lowest was recorded in lufenuron (22.03%).After ten days post treatment, maximum mortality of the pest was recorded in bifenthrin (73.31%) followed by spinosad (60.88%)and emamectin (60.08%), whereas minimum was recorded in lufenuron (16.48%).

Table 1: Data regarding mean comparison of percent mortality of grub of alfalfa weevil after 1st spray on alfalfa crop during, February 2017

S/No	Insecticides		Av. population per tiller of alfalfa weevil before spray	Dose /100 liter water	Post treatment percent mortality of alfalfa weevil after			
	Trade Name	Common Name			3 days Mean±SE	5 days Mean±SE	7 days Mean±SE	10 days Mean±SE
1-	Spintor 480SC	spinosad	49.33	40 ml	75.69±1.26 b	70.14±0.59 b	67.22±0.59 a	60.88±0.44 b
2-	Coragen 20SC	chlorantraniliprole	42.33	25 ml	53.90±0.40bc	63.33±1.09 b	46.01±1.74 b	30.95±1.08 c
3-	Marshal 5EC	lufenuron	41.00	200 ml	37.92±0.83 d	25.84±0.91 e	22.03±1.79 d	16.48±0.35 e
4-	Runner 280SC	methoxyfenozide	54.33	100 ml	46.37±0.83 cd	54.67±0.62 c	22.32±0.30 c	23.20±1.06 d
5-	Emamectin 1.9 EC	emamectin benzoate	40.00	200 ml	79.74±0.34 a	83.5±1.15 a	66.20±1.23 a	60.08±0.29 b
6-	Welthrin 10EC	bifenthrin	37.00	200 ml	82.6±1.39 a	78.21±0.90 a	76.26±1.54 a	73.31±0.96 a
7-	Belt 48 SC	flubendamide	35.67	50 ml	48.96±1.45bc	41.74±0.57 d	36.78±0.29bc	29.51±0.52 cd
8-	Control		36.00	-	0.53±0.05 e	1.10±0.03 f	1.39±0.10 e	1.14±0.03 f
Tukey HSD @ 5%					8.79	7.44	10.67	6.44
F-Value					211.95	353.93	141.11	377.27

Means sharing similar letters are not significantly different by Tukey Test at $P<0.05$ HSD = Honestly Significant Difference

The data on percent mortality of alfalfa weevil grub after 2nd spray were recorded and presented in Table.2 revealed significant differences among various treatments. The results showed that the insecticides bifenthrin (80.27%) and emamectin (74.81%) gave highest mortality of the pest and are statistically similar. The minimum morality of the pest was recorded in lufenuron (34.80%) three days after spray. After five days post treatment, highest mortality of the pest was recorded in bifenthrin (80.75%), statistically similar to emamectin (80.75%) and spinosad (75.78%), lowest mortality was found in lufenuron (31.87%). After seven days of spray, bifenthrin (85.67%) gave highest mortality followed by emamectin (71.64%) and spinosad (71.01%), these are statistically at par with each other. The lowest mortality was recorded in lufenuron (29.98%). After ten days post treatment, maximum mortality of the pest was recorded in bifenthrin (70.02%), emamectin (68.21%) and spinosad (64.62%) followed by coragen (37.81%) and belt (34.05%), whereas minimum was recorded in lufenuron (20.69%).

Table 2: Data regarding mean comparison of percent mortality of alfalfa weevil after second spray on Lucerne crop during, March 2017

S/No	Insecticides		Av. population per tiller of alfalfa weevil before spray	Dose /100 liter water	Post treatment percent mortality of alfalfa weevil after			
	Trade Name	Common Name			3 days Mean±SE	5 days Mean±SE	7 days Mean±SE	10 days Mean±SE
1-	Spintor 480 SC	spinosad	49.33	40 ml	52.36±0.80 b	75.78±1.61abc	71.01±0.63 b	64.62±1.95 a
2-	Coragen 20% SC	chlorantraniliprole	42.33	25 ml	55.83±0.74 b	67.60±0.88bcd	53.89±1.86 c	37.81±1.55 b
3-	Marshal 5%EC	lufenuron	41.00	200 ml	34.80±0.56 d	31.87±0.61 e	29.98±0.64 e	20.69±0.28 d
4-	Runner 280SC	methoxyfenozide	54.33	100 ml	49.81±1.51bc	63.38±2.46 cd	35.63±0.61 e	24.12±0.40 cd
5-	Emamectin1.9 EC	emamectin benzoate	40.00	200 ml	74.81±1.24 a	80.75±0.51 ab	71.64±0.54 b	68.21±0.63 a
6-	Welthrin 10%EC	bifenthrin	37.00	200 ml	80.26±0.78 a	82.97±2.18 a	85.67±0.21 a	70.02±1.82 a
7-	Belt 48 SC	flubendamide	35.67	50 ml	42.92±0.45 c	56.27±2.49 d	44.63±0.16 d	34.04±0.35bc
8-	Control		36.00	-	0.65±0.02 e	0.92±0.04 f	1.79±0.10 f	1.67±0.12 e
Tukey HSD @ 5%					8.08	14.96	7.30	10.46
F-Value					233.67	87.62	343.20	143.94

Means sharing similar letters are not significantly different by Tukey Test at $P<0.05$ HSD = Honestly Significant Difference

The data on cumulative percent mortality of alfalfa weevil grub were presented in Table.3 revealed after three days of spray the insecticides bifenthrin (81.88%) and emamectin (77.28%) caused highest mortality of the pest followed by coragen (54.87%) and spinosad (54.61%). The minimum morality of the pest was observed in lufenuron (36.36%). Similarly after five days, the highest mortality of the pest was recorded in emamectin (82.13%) and bifenthrin (80.59%) followed by spinosad (72.96%) and lowest in lufenuron (28.86%). After seven days of spray, bifenthrin (80.97%) gave highest mortality of the pest followed by spinosad (69.12%) and emamectin (68.92%). The low mortality of the pest was found in lufenuron (26.00%). After ten days post treatment, maximum mortality of the pest was recorded in bifenthrin (71.67%) followed by emamectin (64.15%) and spinosad (62.75%), whereas minimum was recorded in lufenuron (18.59%)

Table 3: Data regarding average mean comparison of percent mortality of alfalfa weevil after first spray and second spray on lucerne crop during 2017

S/No	Insecticides		Dose /100 liter water	Post treatment percent mortality of alfalfa weevil after			
	Trade Name	Common Name		3 days Mean±SE	5 days Mean±SE	7 days Mean±SE	10 days Mean±SE
1-	Spintor 480 SC	spinosad	40 ml	54.61±0.80b	72.96±0.64bc	69.12±0.60 b	62.75±1.19 a
2-	Coragen 20% SC	chlorantraniliprole	25 ml	54.87±0.43 b	65.46±0.98 cd	49.95±1.49 c	34.38±0.24 c
3-	Marshal 5%EC	lufenuron	200 ml	36.36±0.19 d	28.86±0.24 f	26.00±0.76 e	18.59±0.25 d
4-	Runner 280SC	methoxyfenozide	100 ml	48.09±0.79 c	59.02±1.29 d	34.96±0.22 d	23.67±0.54 d
5-	Emamectin 1.9 EC	emamectin benzoate	200 ml	77.28±0.50 a	82.12±0.73 a	68.92±0.82 b	64.15±0.41 b
6-	Welthrin 10%EC	bifenthrin	200 ml	81.43±1.08 a	80.59±1.50 ab	80.97±0.67 a	71.67±1.07 a
7-	Belt 48 SC	flubendamide	50 ml	45.94±0.60 c	49.01±1.06 e	40.70±0.18 d	31.78±0.35 c
8-	Control			0.60±0.03 e	1.01±0.01 g	1.59±0.07 f	1.41±0.07 e
Tukey HSD @ 5%				5.89	8.62	6.82	5.89
F-Value				453.13	261.45	367.87	450.79

Means sharing similar letters are not significantly different by Tukey Test at $P<0.05$ HSD = Honestly Significant Difference

Effect of insecticides on predator population

The population of different predators observed on all treatments before and after applications of insecticides of lucerne variety SGD-2002 was depicted graphically in Fig. 1 and2. The objective of the study was to find out the toxicity of various commonly used insecticides against predators population.

Average population of predators before spray

Average predators population per plot before spray were i.e. 8.70 (Spintor), 5.16 (Coragen), 5.90(Marshal), 4.88(Runner), 3.80 (Emamectin), 8.09 (Belt) and 14.70 (Control).

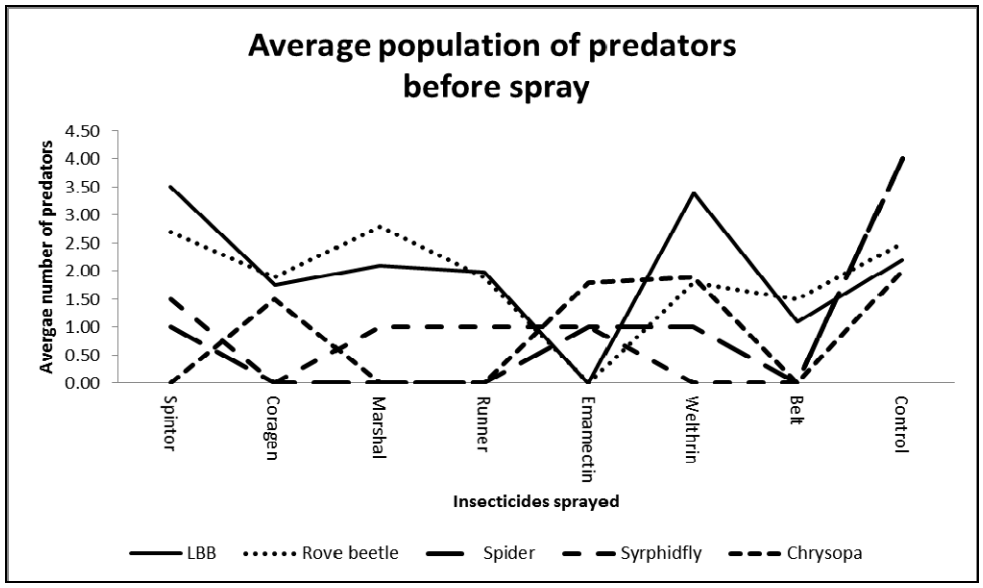

Fig. 1: Average number of existing predators before spray

Graphically shown percent mortality of predators after spray

The population of different predators observed on all treatments after spray of insecticides on lucerne variety SGD-2002 was depicted graphically in Fig. 1. Maximum mortality of ladybird beetle larvae and adult were found in the treatments where belt, Welthrin and Runner were sprayed i.e. 85.33, 83.33 and 80.00 percent. In case of rove beetle, maximum mortality was recorded in Welthrin and marshal i.e. 72.07 and 64.29 percent and minimum was emamectin benzoate i.e. 0.00 percent. Spider maximum mortality was recorded in Welthrin i.e. 62.5 percent, minimum in spinosad i.e. 29.0 percent. Syrphid fly maximum mortality was recorded in the plots where Welthrin and belt was sprayed i.e. 100.00, whereas minimum was recorded in coragen, marshal and emamectin i.e. 0.00 percent

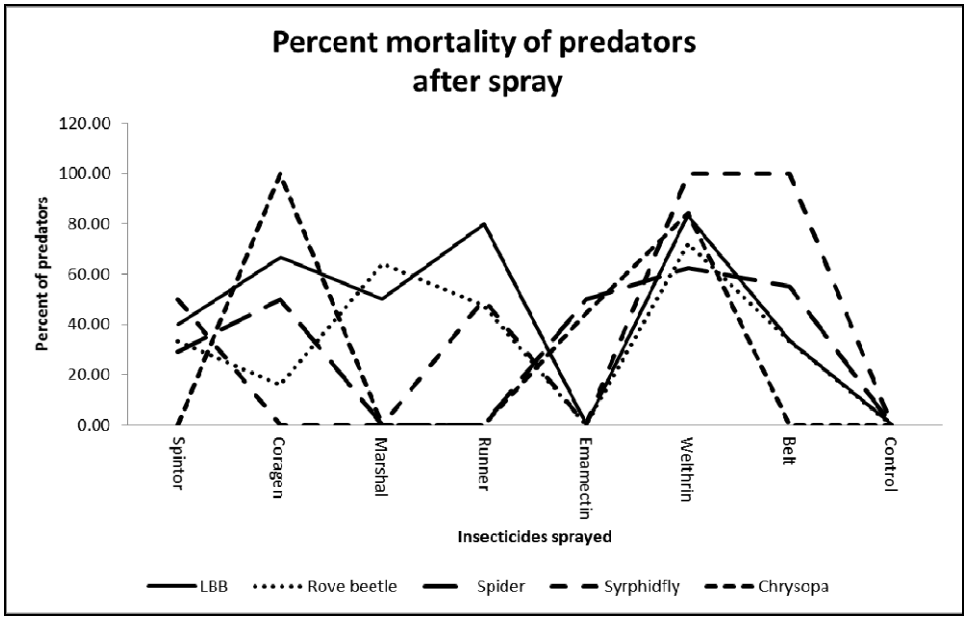

Fig 2: Percent mortality of predators after spray

4. Discussion

Different control measures viz., cultural, biological and chemical are being adopted globally for the management of insect pests on various crops. Among these control measures chemical control is considered to be the best which save the crop from pest outbreak. In our experiment, seven insecticides were tested against grub of alfalfa weevil under field conditions. Our results suggested that all insecticides were statistically different and had significant impact on grub of alfalfa weevil when compared with control plot. On numerical basis, maximum percent mortality was observed in bifenthrin 10EC (81.88%) and emamectin1.9EC (77.28%) @ 200ml per acre and proved more effective insecticide against grub of alfalfa weevil, *Hypera postica* G. as compared with other insecticides followed by coragen 20SC(54.87%) @ 25ml and spinosad 480SC(54.61%) @ 40ml per acre. The minimum morality of the pest was observed in lufenuron 5EC (36.36%) @ 200ml. The results are in agreement with that of [10, 11] who reported that spinosad provides an effective control on key pests globally when tested on insect pest of numerous crops.

Other scientists also agreed that spinosad offers approaches to integrated pest management [12] and resistance management [13] as it provides excellent crop protection with a relatively low toxicity to non- target organisms [14]. Similarly other bio insecticide, emamectin benzoate is a novel semisynthetic derivative of a fermentation product from the soil microorganisms, *Streptomyces avermactitis* [15]. It is shown to be effective against broad spectrum of arthropod pests [16]. The present finding can be compared to Rachael, [17] who reported that spinosad giving about 70% control on weevil of alfalfa crop. However, the results are not in agreement with [18, 19] who reported that furadan was found effective against alfalfa weevil larvae, some others found that azinphos-ethyl, dieldrin and methidathion found effective [20]. Bio insecticides are not only effective against alfalfa weevil but also effective on different kinds of insect pest as reported by Naggar and Jehan, 2013 [21], who concluded that emamectin benzoate was the most toxic insecticides against *Spodoptera littoralis* and oblique banded leafroller [22].Emamectin benzoate toxicity is broader spectrum which is a benefit in that it kills a wide variety of lepidopterans [23]. However, its broad-spectrum activity also makes fresh residues toxic to natural enemies [24]. In our experiment emamectin benzoate and spinosad proved comparatively safe against the predators population. However insecticide bifenthrin is among the most commonly used pyrethroids effective against many insect pests. It has contact, stomach action and non-systemic. It control the insects by interfering with the sodium channels of both the peripheral and central nervous system stimulating repetitive nervous discharges, leading to paralysis [25]. In our experiment bifenthrin gives best results against grub of alfalfa weevil. The results can be compared with that of [26], who reported that chlorpyrifos, alphacypermethrin or high rates of bifenthrin have worked well against small lucerne weevils.

5. Conclusion

The present study indicates that spinosad, emamectin benzoate and bifenthrin are the most effective insecticides against Alfalfa weevil grub for maximum duration as compared to all other insecticides tested. These insecticides have diverse mode of action and can be included in the IPM module which will very helpful in planning future program of pest management and keep them as part of chemical control to avoid resistance and cross-resistance, which ultimately result in better and healthy crop production and increase the GDP of the country.

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