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Research Article

Efficacy of Chemical Insecticide to Control Alfalfa Weevil Larvae in Field of Alfalfa

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ABSTRACT

The alfalfa weevil (*Hypera postica*) is an important pest that causes significant damages to alfalfa crops, reducing yield and quality, but there's a solution. This research had two main goals to evaluate the efficacy of insecticides available in Korea for alfalfa weevil control and to provide data for pest management studies. The experiment, conducted from 2023 to 2024 at the National Institute of Animal Science in Cheonan, Republic of Korea, included four treatment plots: control (CON), early-occurrence (EAR), mid-occurrence (MID), and late-occurrence (LAT). It also included two frequency plots with primary and secondary insecticide using 50% fenitrothion emulsion, which made it truly comprehensive study. The primary insecticide was applied at the first observation of the alfalfa weevil larvae, with subsequent secondary applications at specified intervals. The results showed that two-times insecticide applications significantly reduced larvae populations and increased yield and nutrient content compared to a single application. Specifically, control rates ranged from 94 to 94.7% on the third day after treatment and from 72.2 to 93.4% on the seventh day. Plots with two applications had higher yields and crude protein content. The study concluded that the timing and frequency of insecticide applications are critical to maximizing alfalfa yield and quality, emphasizing the importance of optimized application strategies for effective pest control.

(**Key words**: Alfalfa yield, Weevil larvae, Insecticide effect)

Ⅰ. INTRODUCTION

Alfalfa weevil *(Hypera postica*) is a pest that causes dramatic damage in alfalfa fields. It was native to Eurasia and North Africa, observed in the United States in the early 1900s (Titus, 1910), and it was observed first in 1994 in South Korea and has spread since 2005 (Kim and Gil, 2013). In Korea, the alfalfa weevil population appears to have been sustained by attaching to green manure crops, such as Chinese milkvetch and hairy vetch. Alfalfa weevil larvae occur in alfalfa fields in spring and damage the leaves, greatly reducing yield and quality. Various insecticides are utilized in overseas countries and used to control alfalfa weevil larvae, but only two types of pesticides (Etofenprox and Fenitrothion emulsion) are registered and distributed in the Republic of Korea. Since the residual efficacy of pesticides varies depending on chemical characteristics, weather conditions, and plant characteristics (Lyons and Hageman, 2021), the supply of insecticides suitable for domestic conditions is required. In the United States, which conducted a lot of research on alfalfa weevil in the 1980s and 1990s, the issue of pesticide resistance has been attracting attention again since the 1960s (Rodebell et al., 2022). Koehler and Pimentel (1973) reported the damage caused by alfalfa weevil larvae can reduce alfalfa yield by up to 50%. In Korea, the control of alfalfa weevil has been partially studied in Chinese milkvetch *(Astragalus sinicus*) (Bae et al., 2014), and the leaf damage rate has been reported to reach 80%. However, most of the studies in Korea were limited to eco-friendly control in green manure crops. Adult alfalfa weevils enter alfalfa fields in the fall and overwinter to produce larvae in the spring; managing spring fields of fall sowing or in fields older than one year is important. Since alfalfa has not been cultivated in South Korea, studies on the chemical control of alfalfa weevils are insufficient. Therefore, this study was conducted to verify the chemical control effect of alfalfa weevil larvae insecticides distributed in Korea and to use them as basic research data for control research.

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Ⅱ. MATERIALS AND METHODS

1. Experimental design

This experiment was conducted from 2023-2024, and alfalfa seeded in the fall of 2022-2023. Alfalfa (SW 5615) was cultivated in the field Department of Animal Resources Development, National Institute Animal Science, located in Cheonan, Chungcheongnam-do, Republic of Korea. In a 0.25 ha alfalfa field sown at a rate of 20 kg/ha, a 6 m² area (2 × 3 m) was randomly designated for each experiment, with three repetitions conducted. The 3 × 2 factorial design of experiment plots included three treatment plots, early-occurrence (EAR), mid-occurrence (MID), and late-occurrence (LAT), and two frequency plots involved primary application plots (PAP) and secondary application plots (SAP). It also has an experiment plot of control (CON) for comparison with the treatment plot. The primary insecticide was applied on 0 (EAR), 7 (MID), and 14 (LAT) days following the initial observation of alfalfa weevil larvae, with no insecticide applied in the control plot. Secondary frequency plots received additional insecticide applications at after 7 days from each primary application date.

2. Insecticide control

Daily observations were conducted at 9 a.m. in the alfalfa field, to determine the initial occurrence period of the alfalfa weevil larvae. The first occurrences were observed on March 27, 2023, and April 1, 2024. Using the shake bucket method, 30 stems were sampled from each experimental plot, and the average number of units per stem was assessed for calculating the control value. Insecticide application was then carried out according to the EAR, MID, and LAT schedules. Units per stem were measured three days after each treatment period. The insecticide employed for alfalfa weevil larvae control was 50% fenitrothion emulsions applied by diluting 1000 times, distributed in the Republic of Korea.

3. Forage yield and feed value

Alfalfa was harvested at the 10% flowering stage to measure the production and feed value. The harvest date was at least 20 days after the last insecticide application. At the time of harvest, the height and yield were measured, and dry for analysis of the dry matter. All samples were dried for 72 h in a 65℃ air dryer. Dried samples were pulverized and passed through a 1 mm sieve using a mill for the feed value analysis. All feed value analyses were performed by the Association of Official Analytical Chemists (AOAC, 1990). The crude protein (CP) content was measured using an elemental analyzer (Vario MAX cube; Elementar, Langenselbold, Germany) according to Dumas' method (AAAS, 1884). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed by Goering and Van Soest (1970) using an Ankom200 fiber analyzer (Ankom Technology, Macedon, NY, USA). The relative feed value was calculated using the formula: relative feed value = (120 / NDF (%)) × (88.9 − 0.779 × ADF (%)) / 1.29 (Moore and Undersander, 2002).

4. Statistical analysis

Statistical analysis was conducted to Tukey test ($p<0.05$) using the PROC ANOVA SAS program (v. 9.4 program, 2013) for significant differences between each treatment. For the application effects, data was analyzed as a 3 × 2 factorial design using the PROC MIXED SAS program (v. 9.4 program, 2013).

Table 1. Effects of insecticide period and frequency on alfalfa weevil control value.

	EAR		MID		LAT		AFE	APE
	PAP	SAP	PAP	SAP	PAP	SAP		
3rd day of insecticide application	94.7^{a}	90.9^{b}	91.0^{b}	84.0^{c}	89.1^{b}	90.1^{b}	-	**
7th day of insecticide application	72.2^{b}	76.6^{b}	75.9^{b}	74.4^{b}	89.3^{a}	93.4^{a}	-	*
10th day of insecticide application	64.9^{c}	96.0^{a}	74.1^{b}	97.3^{a}	87.7^{ab}	93.1^{a}	*	*

EAR, experiment plot of 0 days after first observation of alfalfa weevil larvae; MID, experiment plot of 7 days after first observation of alfalfa weevil larvae; LAT, experiment plot of 14 days after first observation of alfalfa weevil larvae; PAP, primary insecticide application plot; SAP, secondary insecticide application plot after from 7 days of primary application plot; AFE, Application frequency effects, application frequency effects with PAP vs. SAP; APE, application period effects with EAR vs. MID vs. LAT; *, $p<0.05$; **, $p<0.01$; -, $p>0.05$;
$^{a\sim c}$ means significant differences in the same row ($p<0.05$).

Ⅲ. RESULTS AND DISCUSSION

1. Insecticide effect

Table 1 shows the insecticidal effect according to the period and frequency of pesticide application, and the average number observed per stem is shown in Figs. 1 and 2. The control value the 3rd day of application after control at each treatment period was 94 to 94.7%, and the control value the 7th day of application after control varied from 72.2 to 93.4%. Since the occurrence of alfalfa weevil larvae takes about 1 to 2 weeks to hatch from the eggs, it is judged that the control was lower in 7th day in the early and mid-term, compared to 3rd day, due to the larvae that hatch later. On the 10th day of application after control, the PAP was lower than that of the SAP in all treatments ($p<0.05$). This is because the larvae that occurred after the first spray were killed by the second application. As shown in Fig. 1 and Fig. 2, all treatment plots after application, showed a lower number of alfalfa weevil larvae than the non-treatment plot ($p<0.05$). After the primary application, the EAR (4.94 vs. 3.03), MID (3.72 vs. 2.16), and LAT (2.22 vs. 1.66) of the frequency plot showed lower alfalfa weevil larvae in the secondary plot. This change is likely attributed to the influence of late-hatched alfalfa weevil larvae. Given that the incubation and growth period of these larvae differ with temperature and environmental conditions, it is crucial to consider these factors when determining the frequency and period of insecticide application. Alfalfa weevil larvae were first observed on 1 April and steadily increased, but no increase in population has been observed since mid-May. This is due to no increase in weevil larvae observed since mid-April due to severe leaf damage. It took approximately two weeks for recovery to occur thereafter.

2. Forage yield

Table 2 shows the height and yield of alfalfa according to the period and frequency of insecticide application. Height in PAP was lower in EAR (86.1 vs. 89.0 cm, $p<0.05$) and MID (84.6 vs. 87.5 cm, $p<0.05$) than in SAP. In dry matter yield (DM yield), PAP was lower than SAP in treatment plots of alfalfa according to the period of EAR (7,324 vs. 9,906 kg/ha, $p<0.05$), MID (6,988 vs. 8,385 kg/ha, $p<0.05$), and LAT (7,052 vs. 8,460 kg/ha, $p<0.05$). Crude protein yield (CP yield) also showed lower PAP in treatment plots of EAR (1,404 vs. 1,597 kg/ha, $p<0.05$), MID (1,456 vs. 1,501 kg/ha, $p<0.05$), LAT (1,423 vs. 1,614 kg/ha, $p<0.05$) compared to SAP, similarly in DM yield. treatment plots were higher than other period treatment plots when applied in early-occurrence, with relatively little influence on the frequency of sprays in late-occurrence. The observed variations in yield based on the period and frequency of insecticide application appear to be due to leaf loss caused by alfalfa weevil larvae. Leaf loss from weevil larvae alone reduces alfalfa yield (Berbert and McNew, 1986), and the energy required for recovery from this damage also contributes to yield loss (Fick and Liu, 1976). Most changes in the production volume of alfalfa were negatively correlated with the presence of weevil larvae. However, there was no significant difference

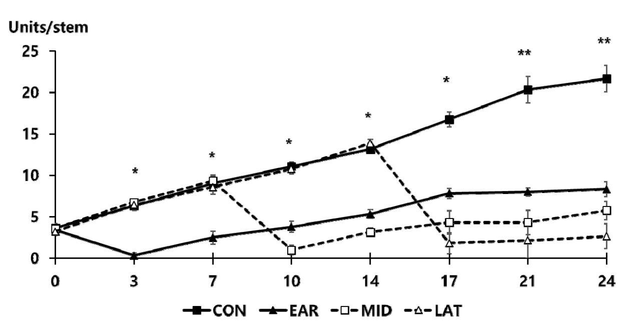

Fig 1. Average units per stem on treatment plots of primary insecticide application. CON, control; EAR, experiment plot of 0 days after first observation of alfalfa weevil larvae; MID, experiment plot of 7 days after first observation of alfalfa weevil larvae; LAT, experiment plot of 14 days after first observation of alfalfa weevil larvae; *, $p<0.05$; **, $p<0.01$.

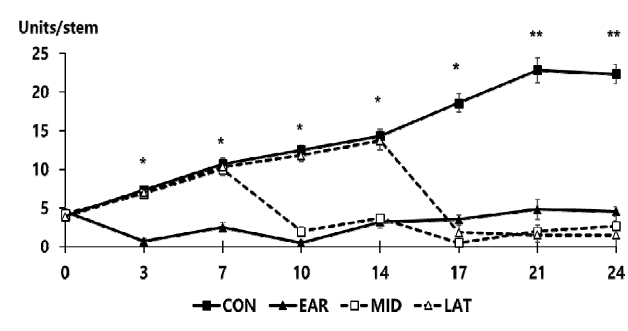

Fig 2. Average units per stem on treatment plots of secondary insecticide application. CON, control; EAR, experiment plot of 0 days after first observation of alfalfa weevil larvae; MID, experiment plot of 7 days after first observation of alfalfa weevil larvae; LAT, experiment plot of 14 days after first observation of alfalfa weevil larvae; *, $p<0.05$; **, $p<0.01$.

Table 2. Effects of insecticide period and frequency on alfalfa height and yield

	CON	EAR		MID		LAT		IE	AFE	APE
		PAP	SAP	PAP	SAP	PAP	SAP			
Height (cm)	83.9	86.1[b]	89.0[a]	84.6[b]	87.5[a]	85.5[b]	84.8[b]	*	*	-
DM yield (kg/ha)	6,360	7,324[c]	9,906[a]	6,988[c]	8,385[b]	7,052[c]	8,460[b]	*	**	*
CP yield (kg/ha)	1,266	1,404[c]	1,597[a]	1,456[b]	1,501[b]	1,423[bc]	1,614[a]	*	**	*

EAR, experiment plot of 0 days after first observation of alfalfa weevil larvae; MID, experiment plot of 7 days after first observation of alfalfa weevil larvae; LAT, experiment plot of 14 days after first observation of alfalfa weevil larvae; PAP, primary insecticide application plot; SAP, secondary insecticide application plot after from 7 days of primary application plot; IE, insecticide effects with control vs. treatments; AFE, Application frequency effects, application frequency effects with PAP vs. SAP; APE, application period effects with EAR vs. MID vs. LAT; *, p <0.05; **, p <0.01; -, p >0.05; DM, dry matter; CP, crude protein.
[a~c] means significant differences in the same row (p<0.05).

Table 3. Effects of insecticide period and frequency on alfalfa chemical compositions

	CON	EAR		MID		LAT		IE	AFE	APE
		SAP	PAP	SAP	PAP	SAP	PAP			
NDF, % of DM	45.3	44.3	44.9	45.7	45.5	44.2	45.7	-	-	-
ADF, % of DM	33.5	32.3[b]	34.1[a]	31.5[b]	33.6[a]	32.6[ab]	32.2[ab]	*	*	*
RFV	129	133.9[a]	129.0[bc]	130.8[b]	128.4[c]	133.7[a]	129.8[b]	*	*	*

EAR, experiment plot of 0 days after first observation of alfalfa weevil larvae; MID, experiment plot of 7 days after first observation of alfalfa weevil larvae; LAT, experiment plot of 14 days after first observation of alfalfa weevil larvae; PAP, primary insecticide application plot; SAP, secondary insecticide application plot after from 7 days of primary application plot; IE, insecticide effects with control vs. treatments; AFE, Application frequency effects, application frequency effects with PAP vs. SAP; APE, application period effects with EAR vs. MID vs. LAT; *, p<0.05; -, p>0.05; DM, dry matter; CP, crude protein.
[a~c] means significant differences in the same row (p<0.05).

(p>0.05) in the number of weevil larvae between the LAT and SAP treatments, but two sprays resulted in significantly higher DM yield and CP yield (p<0.05).

3. Chemical composition

Table 3 shows the chemical composition of alfalfa according to the period and frequency of insecticide application. In NDF and ADF, there was no significant difference between PAP and SAP of the treatment plot according to the application period (p>0.05), but in RFV, PAP was lower than SAP (p<0.05). There was no significant difference in this numerical difference, but it is considered that the EAR and MID showed a slightly higher ADF value in SAP than PAP, and LAT is thought to be the effect of NDF, which is slightly higher in SAP. The most influential indicator of insect damage occurring in alfalfa, including alfalfa weevils, is known as the leaf and stem ratio (L/S ratio). Since alfalfa leaves have two to three times more CP content than stems (Mowat et al., 1965), CP content is known to decrease when leaf drop occurs due to damage caused by weevil larvae. However, leaf loss by pests is inhibited due to energy consumption to regrowth depending on the level of damage, resulting in a small decrease in the L/S ratio (Fick and Liu, 1976; Berberet and McNew, 1986). Total yield is sometimes reduced by about 80% due to a decrease in leaf content (Berbert and McNew, 1986). As a result of this, some delays in maturation can lead to a decrease in height and lead to nutrient value maintenance or an increase in the nutrient value per DM (Fick, 1976). Similarly, in the results of this study, the higher fiber content such as NDF and ADF in SAP compared to PAP and the lower CP content changes are considered to be the result of the mechanism of plant damage caused by damage to alfalfa weevil larvae.

Ⅳ. CONCLUSIONS

This study was conducted to evaluate the effects of the period and frequency of application of insecticide for the control of alfalfa weevil larvae, and the results are in. Two-time applications are more effective in reducing larvae populations and maintaining higher yields and nutrient values compared to one-time applications. These results suggest that the period and frequency of insecticide application significantly affect both the control of alfalfa weevil larvae and the yield and quality of alfalfa. So, it is clear that optimizing insecticide application strategies is crucial for maximizing alfalfa yield and quality.

Ⅴ. ACKNOWLEDGEMENTS

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