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Studies on Selection of Less Toxic Insecticides for the Aerial Control of Pine Needle Gall Midge (*Thecodiplosis japonensis* Uchida et Inouye)

솔잎혹파리 航空 防除用 低毒性 農藥選拔 硏究

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ABSTRACT Trunk implantation method of phosphamidon 50% Lq.is commonly applied to control the pine needle gall midge (*Thecodiplosis japonensis* Uchida et Inouye) Since trunk implantaion is normally practiced during the late Spring, it is often difficult to accommodate necessary labor in rural area. As an alternative, aerial spraying of less toxic insecticide was designed. Usage of less toxic insecticide in the aerial control of pine needle gall midge can reduce the damage to forest ecosystem. The buprofezin, one of the insect growth regulator, was selected at different rate of dilutions and the treatments effects were evaluated at different date and time When 50 times diluted solution of buprofezin 40% SC was treated on different period, there was no significant difference in efficacies. the control efficacies of buprofezin 40% SC was measured by occurrences (%) of gall formation of the pine needle gall midge using a ultra low volume (ULV) sprayer and the dilutions of 10X, 30X and 50X of buprofezin 40% SC gave efficacies. 72.4, 57.6 and 8.4, respectively.

KEY WORDS Pine needle gall midge, aerial control, buprofezin.

초 록 솔잎혹파리 방제는 포스팜 50% 액제를 수간 주입에 의해 수행되고 있으나 약제처리가 농작업이 많은 시기임으로 노동력의 부족으로 인한 실제 방제에 문제점이 있어 항공기를 이용한 약제방제가 필요하여 저독성 약제인 곤충발육저해제 중 Buprofezin 40% 액상수화제가 선발되었고 10배, 30배, 50배로 희석하여 ULV로 살포한 결과 각각 72.4, 57.6, 8.4%의 방제효과를 얻어 항공방제용 약제 선발가능성을 시사하고 있다.

검색어 솔잎혹파리, 항공방제, 브푸로훼진

The pine needle gall midge (*Thecodiploss japonensis* Uchida et Inouye) was first recorded by Takagi (1929) as cite Ko *et al.* (1985) for killing red pine trees in Changgyong-won Palace in Seoul and at a reservoir in Mokpo city, Chollanam-do, which is located at the southwestern extremity of Korean peninsula in 1929. At least 300 trees were found to be damaged by this insect The invasion of this insect from a foreign country was estimated 3~5 years earlier than first finding. During last 70 years the midge spread out nation-wide including Cheju island.

Intensive studies on this insect were carried out in various aspects to suppress its population and minimize its damages. It thus appeared that the experimental results for the control of the insect were selected or applied in various fields Unfortunately, its occurrence has been spread to the whole country. The major practical strategies to control this insect in these days are utilizing parasitoids such as *Inostemma seoulis* Ko, *Inostemma hokpari* Ko, *Inostemma matsutama* Y. et H. and Platygaster matsutama Y. et H. and chemical control method, for instance, phosphamidon can be applied by a

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trunk implantation method during at the stage of emergence from late of May to middle of June (高 1968, 高 등 1985, 朴 1967, 三浦 1963). In studies on the chemical control to the pine needle gall midges, the initial stage was carried out the selections of judicious insecticides by the application of foliar spray (Choi *et al.* 1980, Chung & Ko 1985. 李 1958, 李 1973, 薛 1973). Several insecticides were also selected for the control of the insect with low volume and ultra low volume foliar sprays. The salithion showed the most effective to suppress the gall formation by the pine needle gall midge and the most effective concentration was obtained by the dilutions of 100 times in aqueous solution. The most effective timing for the single application of the foliar spray method was reported as the period of between 9th of May to 1st of July (Choi *et al.* 1980). The application amount of 100 times diluted salithion within forest as compared to those of the other agricultural crop plant control was shown too a lot of amount for control of the insect to practical applications. In these points, the desirable applicated amount of salithion in the pine needle gall midge control was obtained by single ULV foliar spray with the dilutions of 10 to 20 times and the feasible timing of this insecticide application would be from late of May to early of June (Choi *et al.* 1979). Unfortunately, the salithion was limited to practical application in the mountain forest because it has relatively broad-action spectrum of other insects even including natural enemies of the pine needle gall midges.

The trunk implantation of insecticide is generally used in order to select useful insecticide and improve its application method. In the case of phosphamidon, 50% liquid formula was implanted into the tree trunk at the rate of 0.3 ml per cm in diameter of breath height (DBH) by the direct implantation method. A hand drill and a powered machine were used to make holes of 1.2 cm in diameter and 3 cm in depth in practical control settlement (高 등 1985, 小島 1971. 朴 1967, Norris 1967). Nowadays, the chemical control of phosphamidon 50% liquid (Choi *et al.* 1981. Choi *et al.* 1981, 朴 1967) is dependent on the trunk implantation because this method is less harzard to the environments of forestry ecosystems and it still gives higher effects for control of the pine needle gall midges. The detailed elucidation of translocation and its metabolism of phosphamidon by trunk implantation method have been investigated in the pine trees (Lee *et al.* 1993, Lee *et al.* 1993). However, there are several problems in this method. It requires handy application during the control period and overlaps with the work days of agricultural managements for other crops, such as transplanting and sowing of rice. Additionally, the price of labour for the insecticide application was rapidly increased by the development of economic growth and the labours should be supplied by aged men and women in rural districts.

The trunk implantation of acephate (Orthene Medicaps) for the control of western spruce budworm *Choristoneura occidentalis* and douglas fir cone gall midges *Contarinia oregonensis* was reported by the several researchers (Reardon & Haskett 1981, Stein *et al.* 1988). Western spruce budworm and spruce cone worm *Dioryctria reniculloides*, caused most of damages to the cones of douglas-fir and Reardon *et al.* (1985) chose acephate, a systemic insecticide, and injected by the trunk implantation. Acephate capsules (97%) were also used for the pest control of the seeds of *Pinus koraiensis* Sieb. et Zucc and the fall webworm of *Platanus occidentalis* L. in Korea.

Recently, the aerial application of esfenvalerate for control of douglas-fir cone gall midge, *Contarinia oregonensis* (Diptera: Cecidomyiidae) in douglas-fir seed orchards (Sandquist *et al.* 1993) can reduced insect-damage levels with between 10 to 20 times less than when high-volume orchard sprayers are used (Yang *et al.* 1980). However, populations of the spruce spider mite, *Oligonychus ununguis* Jacobi, increased significantly in the treated areas. The *Contarinia oregonensis* is being to the same as family of diptera, the pine needle gall midges (*Thecodiplosis japonensis*) The esfenvalerate, (S)-α-cyano-3-phenoxyphenyl-(S)-2-(4-chlorophenyl)-3-methylbutyrate, one of pyrethroid group, was registered in EPA for both ground and aerial applications in USA. Although the half-life of esfenvalerate is about 7.5 days in sunlight, the aerial application provided insecticidal activity through the period of most emerge-

nce of the gall midges. In some cases, the aerial application of esfenvalerate increased the population of spruce spider mites which was a adverse effect. Although there are seamy sides of aerial control, this method might be useful to control the gall midges in the place where its damage is severe. The aerial control is also very convenient and economical. In experimental results for the aerial control of larch shoot blight on larch stands with fungicides, It required only 12 minutes to spray 360 liters of fungicides to 12 hectares using a Bell 206 helicopter. It was very satisfactory control of the disease with only 2~3 aerial applications and no phytotoxicity was appeared (Yang *et al* 1980). Further more, in classified three categories of pesticides according to their toxicity on the aphidophagous gall midges, *Aphidoletes aphidimyza* for integrated management programs (IMP), buprofezin 25% WP, one of the low toxicity pesticides refered to as insect growth regulators (IGRs) was belonged to the group A (harmless or slightly harmful, 0~30% mortality) and bioresmethrin was only belonged to the group A except the several acaricides (Havelka & Bartova 1993).

In this study, we chose less toxic insecticide in order to minimize the affections to the forestry ecosystem for the aerial control of pine needle gall midges.

MATERIALS AND METHODS

The field-application of less toxic pesticides including the insect growth regulators for the aerial control of pine needle gall midges was carried out in Kumkyo of Meekeum city which is located in Kyunggi gi-do during the June of 1991. The tested chemicals were supplied by manufacturer and supplier companies such as buprofezin 40% SC, 2-Tert-butylimino-3-isopropyl-5-phenyl-1,3,5- thiadiazinan-4-one from Hannong Ltd and pyrifroxyfen 10% EC, 2-11-methyl-2-(phenoxyphenoxry) ethoxyl pyridine from ICI Korea Agrochemicals.

The applications of 50 times diluted insecticides were done by the spray method using a power-driven ultra fine particle sprayer. It was sprayed on shoots of pine trees in 5 trees per replication with 3 replications per insecticide at optimal control period (June 14). The amount of treatment was enough to cover the shoots of pine trees. The control efficacy was determined by counting the gall incidence by pine needle gall midges in newly shoots per tree at middle of September.

The comparisons of control efficacy with buprofezin 40% SC at different dates and times to the pine needle gall midges were performed in the same places which mentioned above The single application was done on the 4th of June and the double applications were done on the 4th of June and the 14th of June in 1991. The application and observation methods in this experiment were discharged the same as mentioned above.

The experiment to measure the control efficacy with buprofezin 40% SC was achieved on the desirable sites of near Hwayangdong which locates in Chungchongbuk-do in the central region of south Korea Buprofezin 40% SC was sprayed at rate of 10, 30, and 50 times dilutions of aqueous solution using ultra low volume (ULV) Sprayer (battery-type of 12 voltages, devised by Union Carbide) on 10th of June in 1992. The application and observation methods in this experiment were followed by the same as mentioned above.

RESULTS AND DISCUSSIONS

The results of less toxic pesticides by the aerial control of pine needle gall midges shows in Table 1 The gall formatiom by the pine needle gall midges on untreated control was showed the 40.4% with average of three replications. Although the buprofezin was not significant difference at Duncan's multiple range test (5%) in two chemicals, the control efficacy of buprofezin was 42 8 and this was more effective than that of pyriproxyfen effect which was 33.7.

The taxonomic position of this insect belongs to the Cecidomyiidae under the order of diptera in Insecta. Two insecticides among the low toxic insecticides in insect growth regulators were done the availability for control of pine needle gall midges in Korea. Especially, the buprofezin was developed for the control of brown planthopper (*Nilaparvata*

Table 1. Effect of low toxic pesticides, buprofezin and pyrifroxyfen, which were diluted 50 times in aquous solution for the aerial control of the pine needle gall midges (*Thecodiplosis japonensis* Uchida et Inouye) in 1991

Chemical	Gall incidence(%)				Control efficacy
	I	II	III	Mean± SD	
Buprofezin 40% SC	24.3	21.2	23.9	23.1± 1.37b	42.8
Pyrifroxyfen 10% EC	28.9	27.5	24.1	26.8± 3.49b	33.7
Untreated	34.7	40.3	46.1	40.4± 8.06a	—

Means followed by a common letters are not significantly different at 5% level by Duncan's multiple range test.

Table 2. Control efficacy of buprofezin 40% SC at rate of 50 times diluted of water solution for the aerial control of pine needle gall midge (*Thecodiplosis japonensis* Uchida et Inouye) at different application times and dates in 1991

Application		Gall incidence (%)				Control efficacy
Time	Date	I	II	III	Mean± SD	
1	June-4	23.3	21.8	22.7	22.6± 1.07b	44.1
1	June-14	24.3	21.2	23.9	23.1± 2.39b	42.8
2	June-4,14	21.9	21.9	18.1	20.6± 3.10b	49.0
	Untreated	34.7	40.3	46.1	40.4± 8.35a	

Means followed by a common letters are not significantly different at 5% level by Duncan's multiple range test.

lugens Stal) which is one of key pests in rice crops. Pyriproxyfen was also developing the control of housefly (*Musca domestica*) and mosquitos (*Culex pipipens* pallen) and reported the desirable insecticide of the harmless or slightly harmful to the natural enemy, *Aphidoletes aphidimyza* (Haveka *et al.* 1993). In these points, the buprofezin was selected for the feasible insecticide to control of pine needle gall midges, even though its efficacy was not significantly higher than that of pyriproxyfen

The control efficacy with buprofezin 40% SC at different dates and times for the aerial control of pine needle gall midges were obtained as indicated in Table 2.

In comparisons to the experimental results of application times and dates with buprofezin 40% SC, there was no significantly difference between times and dates. The results showed, clearly, higher efficacy with double applications, but it was less than we originally expect. The second experiment shown in Table 2 was carried out in same place for the first experiment shown in Table 1. Both experiments showed the similar tendencies which buprofezin application decreased the gall incidence compared to those of the untreated However, the low efficacy of the buprofezin applications was considered to the less incidence of gall formation in untreated plots.

The experimental results of control efficacy with buprofezin 40% SC at different rates of dilution for the aerial control of pine needle gall midges showed as indicated in Table 3

In these results,the higher concentration gives the higher control efficacy. The control efficacies at the rate of 10 and 30 times dilutions of aqueous solution were obtained to 72.4 and 57.6, resepectively, but that of 50 times dilution was appeared to the lower control efficacy of 8.4. These results are not agreed with those experiment No.1 and No.2 as shown in Table 1 and Table 2, respectively. The different reasons in this experimental results were considered to the different occurrences (%) of gall formation at untreated plots.

Finally, the aerial application for the control of target pests was recognized the various attentions before and after treatment of pesticides. The major attentions before the aerial application are the occurrence of target pest, the areas of application, the availabilities of aircraft, equipments and notifiable

Table 3. The comparison of control efficacy with buprofezine 40% SC at different rate of dilutions for aerial control of *pine needle gall midges* (*Thecodiplosis joponensis* Uchide et Inouye) in 1992

Rate of dilution	Gall incidence (%)				Control efficacy
	I	II	III	Mean± SD	
10×	11.8	13.4	24.9	16.7± 10 11c	72.4
30×	26.6	23.4	27.0	25 7± 2.79b	57.6
50×	58 7	50.9	56.9	55.5± 5.78a	8 4
Untreated	65.0	55.9	61.0	60.6± 6.45a	—

Means followed by a common letters are not significantly different at 5% level by Duncan's multiple range test

managements such as protections of beneficial animals includings also decreasing exposures to peoples, non-target organisms. current weather conditions, are also important and they wre under regulations by Oregon Forestry Practice Act. for example, speed wind (<8 04 Km/h), temperature (<21.1°C), RH (< 50%), no current precipitation or foggy condition and foliage free of snow or ice. The main attentions after aerial application are the phytotoxicity, the dispersions by Rhodamine ×B 400, and the damages of beneficial animals (birds, honeybee, silkworm, aquatics) including the control efficacies and the adverse effects (Sandquist *et al.* 1993). The other aspects, the aerial applicatin to control of the larch shoot blight in larch stands with fungicides was performed in Korea, thes results showed that it required 12 minutes to spray 12 hectares with 360 litre of fungicides and obtained the satisfactory efficacies on the disease with 2~3 aerial applications including no phytotoxicity (Yang *et al.* 1980).

In conclusions, we selected the buprofezin which belongs to the lower toxicity pesticide for the aerial control of pine needle gall midges and obtained desirable results with buprofezin. However, it needs to expand more experiments in various research fields such as the mortality mechanisms of buprofezin, the application amounts or times and the safe use to protect beneficial animals in forest ecosystem. before the practical control strategies for the aerial control of pine needle gall midges.

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