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Note

Effect of Imidacloprid on Virus Vector *Laodelphax striatellus* Fallēn in Prevention of Rice Stripe

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INTRODUCTION

The direct sucking damage caused by *Laodelphax striatellus* Fallēn (SBPH) is almost negligible but the case of Hokkaido 1985 was different.[1] SBPH is important as a vector of rice stripe virus (RSV; persistent type virus) in Japan. The infection of RSV has been remained at a relatively low level these fifteen years and one of the important contributing factors is successful introduction of RSV resistant cultivars into practice.[2] On the other hand, the cultivation of resistant variety is recently decreasing due to the unacceptable grain quality. RSV occurrences in epidemic status are not possible to be suppressed by conventional insecticides which are effective mainly against early season pests such as rice water weevil (*Lissorhoptrus oryzophilus* Kuschel) and leaf beetle (*Lema oryzae* Kuwayama). Under these conditions, the effects of imidacloprid on SBPH to prevent virus transmission were studied about the paddy rice transplanted at various timing during the period when vectors were expected to immigrate. This experiment shows a possibility of simultaneous control of SBPH and RSV by imidacloprid one-shot application into nursery boxes at application rate as low as 200 g a.i./ha. The feeding of SBPH from the phloem which is essential for virus transmission seemed to be inhibited by imidacloprid even at the levels lower than lethal dose. These data suggest that a unique chemical mode of action and high susceptibility of SBPH nymph to imidacloprid are more responsible for the lasting efficacy in practice rather than the insecticidal activity of compound itself.

MATERIALS AND METHODS

1. Chemicals and Application

Imidacloprid, 1-[(6-chloro-3-pyridyl) methyl]-*N*-nitro-2-imidazolidin-imine, is a new systemic insecticide invented by Nihon Bayer Agrochem K.K. in 1985.[3–10] At the time of transplanting, the 2% granule formulation of imidacloprid was treated to 2–3 leaf stage of rice seedlings which were raised in nursery boxes ($30 \times 60 \times 3$ cm) at rates of 25, 50 or 100 g/box, 0.5, 1 or 2 g a.i./box (corresponding to 100, 200 or 400 g a.i./ha in the field after transplanting). 3 days after treatment (DAT) of imidacloprid to nursery box, those seedlings were transplanted into the paddy fields of Nihon Bayer Agrochem Experimental Farm in Yuki, Ibaraki, Japan, consisting of 100 m^2 per plot. Imidacloprid 1% granule was applied into the field at the rate of 400 g a.i./ha on June 2, 1989 (14 days after transplanting). Standard plots are conventional sequential treatments of carbosulfan 5% granule box application followed by three foliar sprays of etofenprox carried out at 14 days intervals after transplanting. Experiment was replicated three times.

The alluvial soil at the experimental site was silty clay (clay 32.4%, silt 51.2%, fine sand 13.9% and coarse sand 2.5%). Fertilizers, herbicides and fungicides were applied according to the standard agricultural practice in Ibaraki, Japan.

2. Insect and Plant

Fields were laid out where rice seedlings (variety: Nihonbare) had been transplanted at various timing, early (May 3, 1989), ordinary (May 19, 1989 or May 20, 1988) and late (June 15, 1989), respectively. The local population infectiveness of SBPH was investigated individually by the method of ELISA introduced by Kuhara 1980,[11] and estimated to be 8.0% in 1988 and 14.7% in 1991, respectively. For the biological evaluation, the number of insect/100 hills and the number of tillers infected by RSV on 1000 hills per plot were investigated 5 times at 7 days interval. In addition, at the time of harvest, the yield of 1000 hills per plot was also assessed. These data were subjected to Duncan's new multiple range analysis.

3. Pot Test in Green-House

The SBPH, 90.3% of them had been infected by RSV, was supplied from National Agriculture Research Center/Tsukuba in 1991. Ten female adults within 2–3 days after emergence were released into one pot contained 3 hills of 3–4 leaf stage seedlings and allowed for feeding under the greenhouse condition. The temperature during the test was between 25–30°C. This experiment was replicated three times. For the biological evaluation, the number of insect survivals and plants infected by RSV were investigated at 1, 2, 3 and 21 days after insect inoculation.

RESULTS AND DISCUSSION

Judging from the results of field tests including the yield assessment, a single application of 100 or 200 g imidacloprid/ha is sufficient in practice to prevent the RSV infection by vector control (Tables 1 and 2). The period of efficacy for imidacloprid is highly dependent on the application rate. Efficacy persisted for 40, 70 and 80 days at 100, 200 and 400 g a.i./ha, respectively, being superior over standard carbosulfan 700 g/ha (Table 1). These application rates guarantee equally good ability to suppress rice stripe virus disease under a moderate infection pressure (Table 2). Against SBPH, imidacloprid granules at 200 g a.i./ha showed remarkable efficacy and were far superior to that of a conventional multiple treatment, carbosulfan (700 g a.i./ha) followed by etofenprox foliar spray (100 g a.i./ha × 3) (Fig. 1). Based on our previous study,[12] the concentration of 0.01 mg/kg of imidacloprid seems to be still active to inhibit growth of SBPH at 60 days after transplanting.

In the field where rice seedlings were transplanted at ordinary planting time (May 19, 1989), plots treated with 200 g imidacloprid/ha resulted in the highest yield (Table 3). This yield increase by imidacloprid suggests the result of SBPH control and prevention of the damage caused by RSV. The

Table 1 Efficacy of imidacloprid on *Laodelphax striatellus* by nursery box application.[a]

		No. of nymph/100 hills					
Chemicals	(g a.i./ha)	35	42	56	70	85 days[b]	Aggregated
Imidacloprid	100	2 a	8 a	29 b	17 b	82 b	138 c
	200	3 a	1 a	10 ab	3 a	56 b	73 b
	400	0 a	1 a	2 a	1 a	21 a	25 a
Carbosulfan	700	14 b	238 c	860 c	—[c]	—	>1112
Untreated		55 c	378 c	956 c	161 c	344 c	1894 d

[a] Transplanted on May 20, 1988. Means within columns followed by the same letter are not significantly different ($p<0.05$; Duncan's new multiple range test). [b] Days after transplanting. [c] Not investigated.

Table 2 *Laodelphax striatellus* and rice stripe virus control by nursery box application of imidacloprid.[a]

Chemicals	(g a.i./ha)	R.S. virus control[b] (% of infeceted hill)	Yield[c] (kg/ha)	Ratio
Imidacloprid	100	1.2 a	6404 a	118
	200	0.92 a	6542 a	121
	400	0.70 a	6587 a	122
Carbosulfan	700	8.6 b	5594 b	103
Untreated		8.3 b	5423 b	100

[a] Transplanted on May 20, 1988. Means within columns followed by the same letter are not significantly different ($p<0.05$; Duncan's new multiple range test). [b] Evaluated at 68 days after transplanting. [c] Unhulled rice.

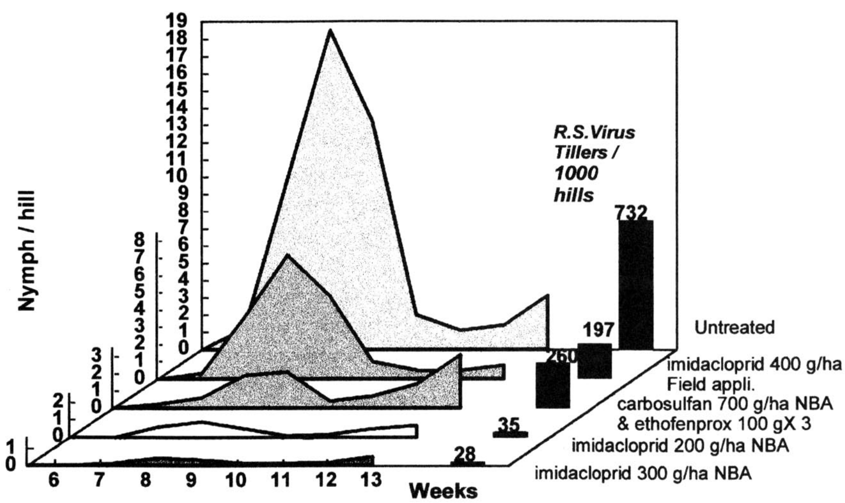

Fig. 1 *L. striatellus* and rice stripe virus control by nursery box application.

Table 3 Rice stripe virus and *Laodelphax striatellus* control by imidacloprid in rice transplanted at different timing.[a)]

Chemicals (g a.i./ha)		Date of transplanting					
		May 3 (early)		May 19 (ordinary)		June 15 (late), 1989	
		% RSV[b)]/Nymph[e)]	Yield[f)] (Ratio)	% RSV[c)]/Nymph[e)]	Yield[f)] (Ratio)	% RSV[d)]/Nymph[e)]	Yield[f)] (Ratio)
Imidacloprid	200	2.03 a/54 b	464 ab (106)	2.34 a/20 b	432 a (116)	0.97 a/2.9 b	406 a (112)
	300	1.13 a/20 a	486 a (111)	1.60 a/9 a	451 a (121)	1.17 a/1.4 a	402 a (110)
Untreated		8.06 b/220 c	437 b (100)	30.3 b/489 c	372 b (100)	7.31 b/54 c	364 b (100)

[a)] Means followed by the same letter are not significantly different at $p<0.05$ by Duncan's new multiple range test; average of 3 replications. RSV: rice stripe virus. [b),c),d)] Evaluation was made at 104, 101 and 82 DATP, respectively. [e)] Averaged number of nymph/50 hills. [f)] Yield: Unhulled rice kg/ha.

Table 4 *Laodelphax striatellus*: The mortality and transmission of rice stripe virus relationship.

Chemicals	(a.i.)	DAT[c)]	Mortality (%)[a)] 24 hr	48	72	R.S. virus %[b)] infected
Imidacloprid	50 g/ha	19	10	37	60	0
	200 g/ha	19	54	63	97	0
Etofenprox	0.01 %	6	40	47	60	93
Untreated		—	0	0	17	100

[a)] Mean of 3 replicates, each replicate used 10 female adults. [b)] Mean of 15 plants tested, 21 days after inoculation. [c)] Time of insect inoculation; days after transplanting.

economic threshold level of SBPH density for RSV control is much lower than that as a sap sucker in general,[2,13)] however, a single application of 200 g imidacloprid/ha is sufficient to suppress the infection of RSV at an economically negligible level for the entire season in the condition of moderate epidemic status regardless of the rice planting time. The early or late planting seems to be beneficial for rice avoiding RSV infection (Tables 2 and 3). RSV transmission to rice usually occurs during the first few weeks after transplanting when the rice is susceptible to RSV.[2)] This means the protection of crops in this sensitive stage could be a promising target when we consider the efficiency of vector control by pesticide.

As already reported on *Nephotettix cincticeps* (GRLH) by Maruyama *etc.*, soon after ingesting the chemical from the vessel, GRLH stopped immediately the feeding and the ingestion from the phloem which is essential for virus transmission was totally inhibited.[14,15)] The relationship between the mortality of SBPH and the RSV transmission was studied under green-house condition. The conventional insecticide (etofenprox) controlled RSV simply by killing the vector SBPH. In contrast, imidacloprid depressed the RSV in the manner of not linking with mortality (Table 4). These data suggest that imidacloprid prevents the transmission of RSV inhibiting the sucking action of planthoppers even at the levels lower than lethal dose by paralyzing behavioral movement. Further field studies are needed to clarify the effects when RSV is at epidemic status.

CONCLUSION

Targeting the most sensitive life stage of SBPH, imidacloprid demonstrated a possibility of simultaneous control of *Laodelphax striatellus* (SBPH) and rice stripe virus (RSV) by one-shot application into nursery boxes at corresponding rate of 200 g a.i./ha. In green-house test, imidacloprid prevented persistent virus transmission by depressing feeding of virus vector SBPH at even lower chemical concentration than lethal dose. These data suggest that the unique chemical mode of action and the high susceptibility of SBPH nymph to imidacloprid are more responsible for the lasting efficacy in practice rather than the insecticidal activity of compound itself.

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要　約

イミダクロプリド育苗箱施用のウイルス媒介昆虫ヒメトビウンカに対する効果と稲縞葉枯病の防除

岩谷宏司，丸山宗之，中西秀明，榎本智臣

イミダクロプリド粒剤による育苗箱施用はヒメトビウンカ（SBPH）の寄生密度を低く抑え，SBPHによって媒介される永続型ウイルス稲縞葉枯病の感染を抑制し慣行の体系防除に優る効果を示した．また，保毒虫を接種して実施したポット試験の結果，イミダクロプリドは死亡に至らない低い濃度でも稲縞葉枯病の感染を効果的に抑制した．ウイルスの感染に重要な篩管からの長期の吸汁阻害がイミダクロプリドの圃場における安定した効果の要因の一つとして考えられる．