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Note

Concentration of Imidacloprid in Rice Plants and Biological Effect on *Nilaparvata lugens* (STÅL)

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INTRODUCTION

Imidacloprid, 1-[(6-chloro-3-pyridyl) methyl]-*N*-nitro-2-imidazolidin-imine, is a new systemic insecticide suitable for use in the form of granules.[1,2] Owing to its high insecticidal activity, selective toxicity and adequate stability in the environment, imidacloprid was found to be able to reduce the application rate and frequency.[3-7] On the other hands, *Nilaparvata lugens* (STÅL) (brown planthopper: BPH) is known to immigrate annually into Japan during the rainy season and often causes destructive damage for rice production. Its density and period of migration fluctuate very much depending on years and regions. Accordingly, the lasting efficacy of insecticides applied at the time of transplanting has been seldom studied under the natural conditions, and clear-cut results are not available so far.

This experiment was carried out to estimate the lasting efficacy of imidacloprid on BPH by the test method combined with artificial insect inoculation and chemical residue analysis. With the high selectivity and systemic property in complex with modern formulation and application technology such as nursery box and seed treatments, imidacloprid may play an important role in the integrated pest management (IPM) program in future.

MATERIALS AND METHODS

1. *Chemicals and Application*

On May 12, 1990 the granule formulation of imidacloprid 2% was treated to 2-3 leaf stage of rice seedlings of Japonica rice variety "Nihonbare" which were raised in nursery boxes ($30 \times 60 \times 3$ cm) at rate of 50 g/box, 1 g a.i./box (corresponding to 200 g active ingredient/ha in the field after transplanting). Three days after treatment (DAT), those seedlings were transplanted into the paddy field of Nihon Bayer Agrochem Experimental Farm in Yuki, Ibaraki Japan, consisting with 100 m^2 per plot and three replicates. Samples of rice plants for analysis were taken at 3 DAT, just before the transplanting, and at a weekly interval for 3 months from the field. The whole plants were divided into root and aerial parts. From 28 days after transplanting (DATP), the aerial parts were subdivided into leaf, sheath and grain (at the harvest time only). Residue analysis was made by HPLC method described by Ishii *et al.*[8]

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*

For the biological evaluation, a part of plot holding six rice hills were covered with a synthetic fiber (SARAN) net ($60 \times 60 \times$ height 120 cm) and kept in that condition until harvest. The insect tested is *Nilaparvata lugens* (BPH), collected in Kagoshima, Japan, in 1982 and has been reared in Yuki laboratory according to the method of Sugimoto giving continuos chemical pressures of 250 ppm propoxur and 500 ppm malathion (LD_{50} value of imidacloprid was 0.20 μg/g).[9] Five male and ten female adults within 2 days after emergence were released into one net and allowed for oviposition during the period of 36 to 85 DATP. For the biological evaluation, the number of insect were counted 12 times at 7 days interval. In addition, at the time of harvest, the yield of 6 hills per plot was also investigated. These data were subjected to Duncan's new multiple range analysis.

We report here the lasting efficacy of imidacloprid on BPH in correlation with its chemical concentration in rice plants when applied in the formulation of granule at the time of transplanting (so-called nursery box application: NBA).

RESULTS AND DISCUSSION

The chemical residue values of imidacloprid are shown in Table 1. The residue of imidacloprid in rice plant was the highest at 3 DAT (93.9 mg/kg) and declined quickly (0.17, 0.011 and 0.004 mg/kg at 28, 63 and 91 DATP, respectively). Also in the root, high residue of 65.7 mg/kg was found at 3 DAT. This indicates that imidacloprid was incorporated into the rice plants rapidly from root during three days. After the transplanting to the paddy field, the residues show a tendency to decrease linearly. The residue in the root was also declined to 0.152 mg/kg at 21 DATP.

Under the condition mentioned above, the rice plants in the two plots among the untreated three were heavily damaged by so-called hopper-burn just before heading stage. The lowest effective concentration of imidacloprid on BPH was estimated to be as low as 0.01 mg/kg in the aerial whole and 0.008 mg/kg in sheath respectively (Table 1, Fig. 1). The concentration of 0.01 mg/kg was still active to inhibit growth of BPH at 8 weeks after transplanting, although sufficient mortality against adult could not be expected at 0.064 mg/kg as early as 5 weeks after transplanting (Tables 1 and 2). The chemical

Table 1 Residue behavior of imidacloprid in rice plant.

DATP[a]	Aerial part (mg/kg)			Root (mg/kg)	A. parts weight
	Whole	L. blades	Sheath		
0[b]	93.9 (91.6-96.2)			65.7 (62.1-69.2)	0.24
7	10.9 (10.3-11.5)			7.51 (7.27-7.74)	0.42
14	2.22 (2.18-2.25)			0.95 (0.927-0.973)	0.85
21	0.326 (0.302-0.349)			0.152 (0.136-0.168)	3.89
28	0.170	0.364 (0.351-0.378)	0.044 (0.043-0.046)	0.077 (0.076-0.078)	9.43
35	0.064	0.126 (0.124-0.129)	0.025 (0.024-0.026)	0.060 (0.059-0.062)	25
42	0.028	0.054 (0.054-0.055)	0.013 (0.013-0.013)		58
50		0.017 (0.017-0.018)	0.007 (0.007-0.007)		70
63	0.011	0.018 (0.017-0.020)	0.008 (0.008-0.008)		121
77	0.008	0.015 (0.014-0.016)	0.004 (0.003-0.006)		161
91	0.004	0.007 (0.006-0.009)	0.002 (0.002-0.002)		257
120	0.002 (0.002-0.002)[c]				(g/hill)

[a] Days after transplanting. [b] 3 days after treatment. [c] Residue in grain.

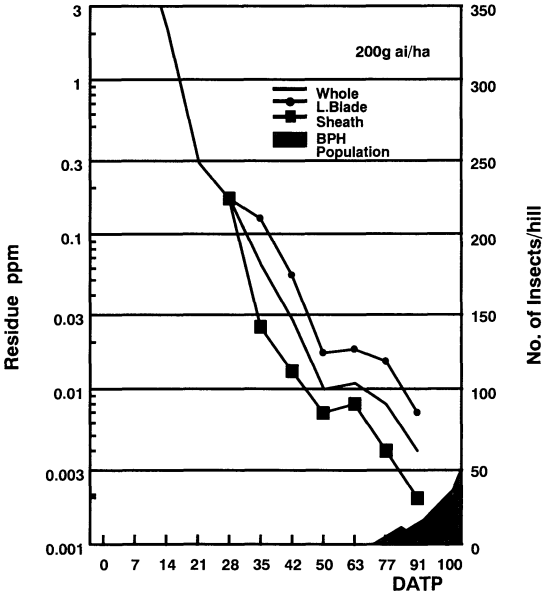

Fig. 1. Chemical residue and effect of imidacloprid 200 g/ha on BPH.

concentration of sheaths, the parts where BPH preferably make oviposition and infests, will be more important for BPH control than that of leaf blades. Even though the concentration in the sheaths were one eighth to half of those of leaf blades. The final crop residue in grain was 0.002 mg/kg, 1/100 of Japanese MRL 0.2 mg/kg, and as low as the minimum detectable concentration.

On the other hand, the efficacy of NBA with imidacloprid granules against BPH lasted 3 months at the application rate of 200 g a.i./ha and exceeded 100 days at 300 g (Table 2). In the plots treated with 200 g imidacloprid/ha, a reinfestation with BPH was observed in mid August at 91 DATP, it was proved that the crop had suffered scarcely from hopper damage until the harvest as shown in yield assessment (Table 3).

Table 2 Efficacy of imidacloprid on BPH by N.B. application.

DATP[a]	No. of nymph [Adult]/6 hills		
	Imidacloprid (g/ha)		Untreatment
	300	200	
38	[6][ns]	[8][ns]	[11]
51	4.7 (3-7)**	3.7 (1-6)**	49.0 (44-57)
58	4.3 (4-5)**	3.3 (2-4)**	44.0 (40-48)
65	8.7 (1-19)*	6.3 (0-17)**	42.7 (28-62)
72	16.3 (12-23)[ns]	23.7 (18-28)[ns]	234 (14-368)
80	45.0 (20-82)[ns]	104 (63-154)[ns]	416 (114-784)
86	42.3 (18-71)*	86.0 (36-152)*	685 (298-1042)
93	64.3 (29-99)**	129 (81-188)**	923 (534-1278)
100	52.3 (42-64)*	252 (166-410)*	4400 (606-6414)
108	132 (7-252)*	1036 (210-2368)*	10,592 (3792-16,120)

** Figures indicate significant difference from untreatment with 99% confidence limits. * Figures indicate significant difference from untreatment with 95% confidence limits. [ns] Not significant.

Table 3 Yield assessment.

		Imidacloprid a.i./ha		Untreat.
		300 g	200 g	
Unposished rice	(1)	19.7	19.0	1.1
	(2)	19.9	20.9	2.4
	(3)	18.7	18.5	5.0
	Mean	19.4**	19.5*	2.8
Unhulled rice	(1)	24.2	23.1	1.5
	(2)	24.3	25.7	3.1
	(3)	23.6	22.5	6.2
	Mean	24.0**	23.8*	3.6
(ton/ha)		4.8	4.76	0.72

** Figures indicate significant difference from untreatment with 99% confidence limits.

From the result of the crop damage in response to the concentration of imidacloprid, a single application of 200 g imidacloprid/ha was sufficient in practice to keep the BPH population at an economically negligible level for the entire season. The effect of season-long control which has been observed in the practical fields was confirmed in this test.

CONCLUSION

This experiment showed a possibility of season-long control of BPH by one-shot application of imidacloprid into nursery boxes at corresponding rate of 200 g a.i./ha. The chemical residue effective for BPH is as low as 0.01 mg/kg and the final crop residue in rice grain was only 0.002 mg/kg. These data suggest that the high susceptibility of BPH to imidacloprid is a key factor contributing for the lasting efficacy rather than the chemical persistence in plant itself.

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要　　約

イミダクロプリドの育苗箱施用におけるイネ体濃度の消長とトビイロウンカに対する残効性

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トビイロウンカの人為接種とイネ体中の殺虫剤の残留分析を経時的に組み合わせる手法により，育苗箱施用されたイミダクロプリドの長期にわたる残効性を実験的に解析した．飛来性害虫トビイロウンカに対してイミダクロプリド有効成分 1 g/箱 (200 g a.i./ha) は田植え後約 2 か月間，0.01 mg/kg のイネ体濃度までウンカの増殖を抑制し，100 日を過ぎて密度の回復が見られたものの被害に至らず，収量に影響を及ぼさない許容範囲にあると考えられた．また，収穫された籾の残留値は 0.002 mg/kg で日本における MRL 0.2 mg/kg の 100 分の 1 と，検出限界濃度に近い低いレベルであった．