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Studies on Economic Damage of Korean Rice Pests

H. D. Catling and S. C. Lee*

FAO Plant Protection Project, Suweon, Korea
*Institute of Agricultural Science, Suweon, Korea

벼害虫의 經濟的 被害에 關한 研究

H.D. Catling・李升燦

作物保護研究訓練强化事業機構
*農村振興廳 農業技術研究所

ABSTRACT

Four experiments were carried out under farmer's field conditions to determine economic threshold levels of major rice pests and attempt a reduction in the number of insecticide applications. In the experiments were included check treatments, insecticide schedules representing the official recommendations to farmers, and several corrective treatments. A careful record was kept of insect pest densities and disease incidence.

i) In the north at Suweon and Icheon where *Chilo suppresalis.* (Walk.), the striped rice borer, was active in the first generation, no significant yield differences were obtained between plots receiving several insecticide applications and those left totally unprotected. The mean yields were high (5.2—7.6t/ha).

ii) First generation borer activity rising to 8.6% injured tillers was below the economic threshold since no yield reduction was recorded in either japonica varieties or the high-yielding Tongil variety.

iii) Evidence was obtained that borer damage was made good by replacement of infested tillers (compensatory growth). *C. suppressalis* populations were always low in the second generation.

iv) The experimental results obtained at Suweon and Icheon do not justify the present official recommendations of 6—7 pesticide applications.

v) Further south at Iri a substantial yield reduction occurred due to an early outbreak of stripe disease transmitted by *Laodelphax striatellus* (Fallén), the small brown planthopper; a mean of 1-2 individuals/hill was recorded immediately after transplanting. *C. suppressalis* probably contributed to this yield reduction.

vi) Several applications against the vector failed to prevent the rapid spread of stripe to the susceptible variety in the Iri experiment; in surrounding fields the resistant Tongil varivety was ralatively unaffected.

vii) Pests of lesser importance were *Nephotettix cinctieps* (Uhler), *Nilaparvata lugens* (Stål), *Sogatella furcifera* (Horv.), and leaf miners.

INTRODUCTION

Despite exhaustive work in Korea on chemical control, studied on varietal resitance, and the development of a pest forecasting system, little attention has been paid to the accurate determination of crop losses in rice due to insect pests and diseases. There has been a tendency to equate crop injury with crop loss or make simple estimates of crop loss making no allowance for compensatory growth. In fact, no field experiments have yet been reported which attempt to directly determine crop loss due to the main pests-including the striped borer, *Chilo suppressalis* (Walk.), the main and key pest of rice in Korea (Anonymous, 1973). Crop losses in rice were estimated at 20.8%, about one third, 7.4%, being ascribed to insect pests (Anymous, 1968).

As in neighbouring Japan and Taiwan, pesticides have been used in Korea at a steadily increasing rate during the past decade. In 1965 Korean farmers applied an average of slightly less than one application to their annual rice crop. Based on actual pesticide consumption this rose to a national average of about three applications in 1971 and nearly four in 1974. During 1972 farmers in some important rice-growing areas (e.g. Haenam) made 10 applications; several plots on Government research stations demonstrating new high-yielding varieties 15 applications of pesticide. Present recommendations call for 5-6 applications to standard japonica varieties and 6-7 for the new high-yeilding Tongil lines which are more susceptible to certain pests and disease. In such a control strategy the dangers and side-effects of heavy pesticide use are generally overlooked or underestimated and alternative measures rarely considered. Already some of the classic signs of excessive pesticide use are apparent in Korea (Catling, 1973).

The field experiments described here were designed to start fixing the economic threshold levels of main rice pests, determine whether current pest control recommendations are justified, and ascertain whether the number of applications can be reduced.

METHODS

Experimental sites. In 1973 three field experiments were carried out; one at Suweon in a farmer's field, one at Icheon 35 km east of Suweon, and another at Iri 175 km south of Suweon. Another experiment was conducted at Icheon in 1974.

Experimental lay-out. Randomized complete blocks; five replications; plot size 90m^2 except for Suweon at 63m^2; plot shape near to square. From wind roses drawn for Suweon and Iri no predominant wind direction was indicated and thus no special lay-out was used to reduce the effects of uneven distribution of insects. The 1973 experiments were laid out to accommodate eight treatments, six to receive corrective applications depending on pest densities indicated by regular insect counts. However, only 4—5 different treatments were applied leaving more than one check treatment. The 1974 experiment consisted of five treatments including a single check treatment.

Cultural details. Varieties; Minehikari (Suweon), Akibare (Iri), Tongil (Icheon) Standard fertilization, spacing, irrigation and weed control were practised. Transplanting took place at the end of May or early June, harvesting at the end of September or in October. All cultural practices were typical of the surrounding farmers. Yield determinations were made by harvesting a random 20 m^2 area in each plot.

Insect counts. C. suppressalis and major hopper species were assessed, mostly at weekly intervals, by direct counts of rice hills from the seedbed stage to harves- ting. Direct counts were made on 20—45 hills/plot, lower numbers being taken towards the end of the sea son when the hills were larger and the insect popula tions clearly below economic threshold levels. *C. sup pressalis* density was measured by counting egg masses sheath damage and dead hearts in the first generation and whiteheads in 20 m^2/plot immediately prior t harvesting. Tillers with sheath damage or with dea heart were recorded as "injured". In addition, hoppe were sampled at less regular intervals by sweepnetti up to heading stage at 10 sweeps/plot. Also observatio were made on other insects, diseases and plant growt

Insecticide treatments. Besides the unsprayed chec the following treatments, based on the official Gove ment pest forecasting system, were used in vari combinations: a) very early (vE) applied seven da after transplanting against first generation *C. suppr salis*; b) early (E) applied 4—7 days after peak m activity of first generation, early to mid tillering st late (L) applied 4-7 days after peak moth activity f generation, early to mid heading stage. Pesticides ere applied to seedbeds on a corrective basis. Insecticides, used at standard rates, were largely those selecve materials commonly used in Korea: cartap WP Padan), chlorphenamidine WP or G (Galecron), diainon EC (Vasudin), fenthion EC (Lebaycid). No peicides were applied for disease control.

RESULTS

***uweon*-1973**

No insecticides were necessary for the seedbed. There was a single early treatment of chlorphenamdine (E) an early treatment of chlorphenamidine followed by a late treatment of cartap (E+L); and a single late treatment of cartap (L).

Damage by *C. suppressalis* larvae increased during the first generation, the assessment on July 11 indicating an average of 1.15 injured tillers/hill in untreated plots (Fig. 1.). Less damage occurred in plots receiving an early treatment but due mainly to between plot variation these differences were not statistically signifcant. Numbers of whiteheads at harvesting were low (less than 0.2%), treated plots having fewer whiteheads.

Table 1. Yields of raw rice in metric tons per hectare (t/ha) at experimental sites in Korea. Insecticide treatments: O-check (no insecticide); vE-very early; E-early; M-medium; L-late.

Suweon 1973		*Icheon* 1973		*Iri* 1973		*Icheon* 1974	
O	5.18t/ha	O	7.28t/ha	O	0.83t/ha	O	7.68t/ha
E	5.10	E	7.70	E+M	1.50	E	7.75
E+L	5.40	E+L	7.70	E+M+L	1.50	E+L	7.62
L	4.98	L	7.60	M	1.25	L	7.70
CV-	5.80%	CV-	3.36%	M+L	1.15	vE+E+L	7.72
N.S.		N·S.		CV-	21.23%	CV-	4.77%
				Significant F=6.19**		N.S.	

Hopper populations were low until early Augst when peak of *Laodelphax striatellus* (Fallén), the small own planthopper, and a small rise of *Sogatella furcia* (Horv.), white back planthopper, were recorded —9 individuals/hill, both species), but by this time hills were large enough to tolerate such densities. symptoms of virus disease were observed. Low nbers of *Nilaparvata lugens* (Stål), brown plantpper, appeared at the end of July. Leaf miner dam- was fairly severe soon after treatments large nbers of adults being collected in sweepnets towards end of June, but a complete recovery took place ing the tillering stage.

Yield differences between treatentms were non-signiint (Table 1).

***eon*-1973**

Again, no treatments were necessary for the seedbed. same schedule of treatments was applied as at veon except that the early treatment was applied one k later to correspond with the timming of surroung farmers.

lightly higher numbers of *C. suppressalis* eggs were rded than at Suweon. Mean larval damage for all plots receiving no insecticide by July 12 was 40.2% injured hills and 1.38 injured tillers/hill (Fig. 1). For the treated plots the means were 25.0 and 0.48 respectively, these differences being statistically significant (F=3.59**). Numbers of whiteheads were slightly higher than Suweon—0.09-0.28% in treated and 0.83% in untreated plots. Differences in percentage whiteheads between sprayed and unsprayed, and between one and two applications, were statistically significant (F=4.87**).

Hopper populations were lower than Suweon, small peaks of *L. striatellus* and *S. furcifera* being recorded in early August, and thus no specific hopper sprays were applied. As at Suweon, no symptoms of virus disease were observed. The occurrence of other insects was also very similar, *N. lugens* appearing in low numbers from July onwards.

Small yield difference between treatments were not significant (Table 1).

***Iri*-1973**

A very different pattern of insect abundance occurred at Iri. The season started with high population densities of *L. striatellus*, the seedbed receiving two applications of diazinon. On June 21 an early (E) spray of fenthion was applied aganst *L. striatellus* at population densities of 1—2 individuals/hill (Fig. 2) and first generation *C. suppressalis*, to experiment treatments 2, 3 and 4. Fenthion was applied again (M) to experiment 2—7 on July 6 when another outbreak of *L. striatellus* occurred. A late spray (L) of cartap was applied on August 18 for second generation *C. suppressalis*. The Iri experiment thus consisted of the following treatments: unsprayed check; E+M; E+M+L; M;M+L.

Damage by *C. supperessalis* larvae was considerably higher than at Suweon or Icheon (Fig. 1). On July 10 all hills in unsprayed plots were damaged with means of 3.7 — 4.4 injured tillers/hill, while in the three

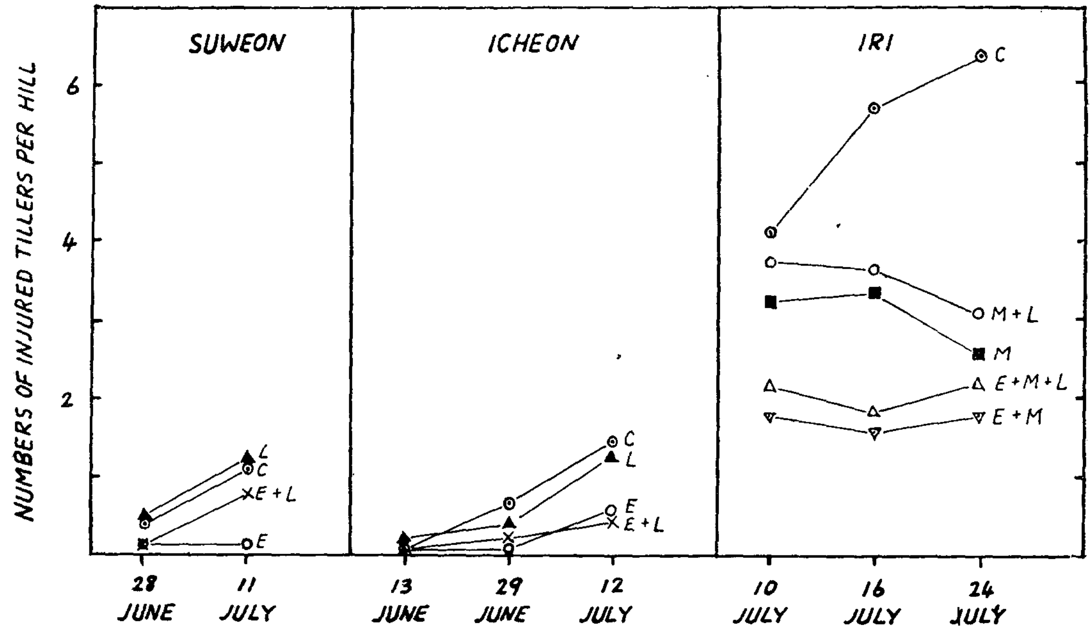


Fig. 1. Larval activity of first generation *Chilo suppressalis* (Walk.) in three experiments in Korea, 1973, according to various insecticide schedules. Check-no insecticide, E-early application, M-medium, L-late.

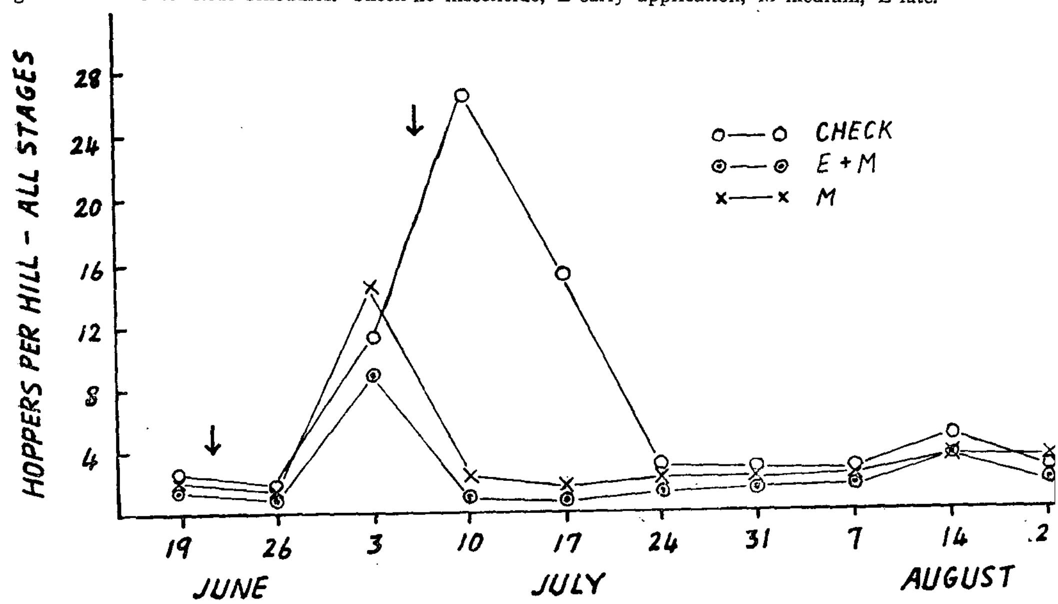


Fig. 2. Population fluctuations of *Laodelphax striatellus*(Fallén) at Iri, Korea, in 1973 according to various secticide schedules. Chcek-no insecticide, E-early application, M-medium. Arrows indicatetiming of sprays agai *L. striatellus*. A late application is not shown since it had little effect on the population.

sprayed treatments 78—88% of the hills were damaged with 1.7—2.7 injured tillers/hill. By July 24 there were >6 injured tillers/hill in the unsprayed plots. Differences in larval damage between sprayed and unsprayed treatments were highly significent (F=18.9**). Though numbers of whiteheads were low and treatment differences were non-significant, there was a tendency for fewer whitheads in sprayed plots and none were recorded n the plots receiving early sprays.

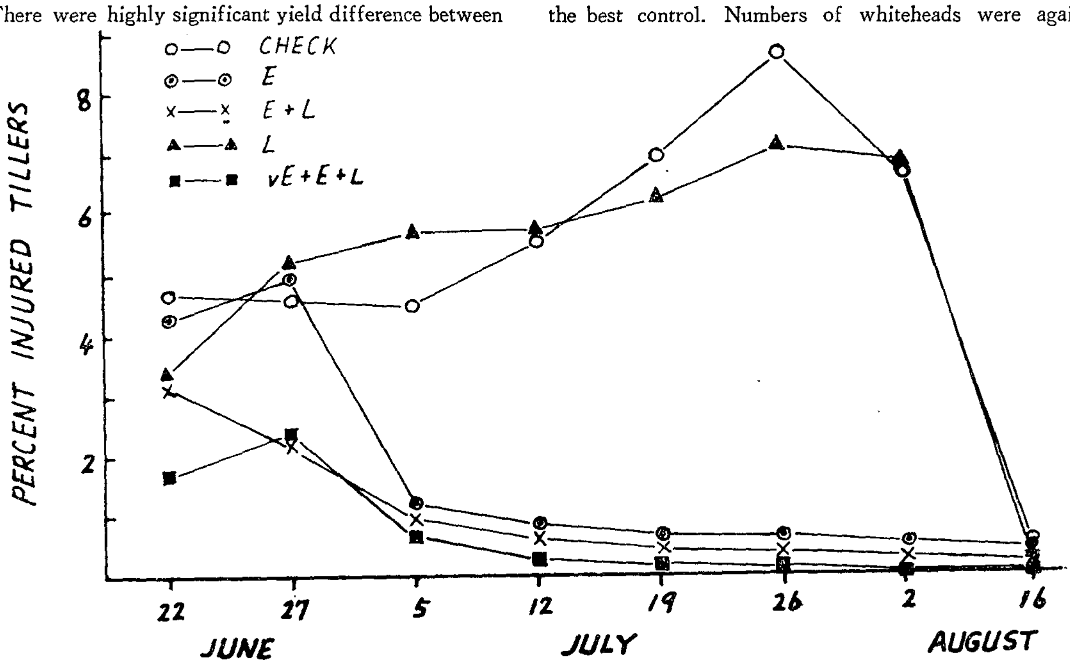
Nephotettix cincticeps(Uhler), rice green leafhopper, was most abundant at the end of August (3/hill); *N. ugens* peaked a month later, both species being more umerous than at the other sites. *S. furcifera* was gain unimportant. On the other hand, severe *L. stritellus* outbreaks occurred early in the season (Fig.2). The spray applied on June 21 when the populations as mainly in the adult stage was not effective for, 12 ays later, densities had risen to an average of 11.5/ ll. The second spray, applied on July 6 when nymphs ere predominant, resulted in a high mortality, the pulation stabilizing around 2—4/hill for the rest of e season. Stripe disease, first observed on June 26, as evident in 47—64% of the hills in July. Differences stripe incidence between sprayed and unsprayed treatents were not significant.

There were highly significant yield difference between treatments (Table 1). The mean yield for sprayed treatments E+M and E+M+L(1.50t/ha) was significantly higher than that for the two unsprayed treatments (0.83t/ha).

Icheon–1974

Another experiment on the Tongil variety was carried out at the same site the following year. No insect control was necessary on the seedbed. Treatments were the same as in 1973 except that an additional very early (vE) application was made seven days after transplanting. Cartap was used for vE and E treatments, chlorphenamidine for L treatments. In this experiment all counts were made at seven day intervals, including observations on plant growth in order to study the mechanism of compensatory growth.

Fig. 3 shows that the percentage of tillers injured by *C. suppressalis* for check and L treatments varied from 4.4—8.6% between June 22 and August 2 (first generation); the percentage of injured hills varied from 21—46. After June those plots which received an early application showed less than 1.3% injured tillers and 11% injured hills, these difference being statistically significcant (F=20.06**) The check and L treatments showed very similar borer densities. For all other treatments the record was fairly consistent, vE+E+L giving the best control. Numbers of whiteheads were again



3. Larval activity of first generation *Chilo suppressalis* (Walk.) at Icheon, Korea, in 1974 according to rious insecticide schedules. Check-no insecticide, vE-very early application, E-early, L-late.

low: 0.86% for check, 0.12% for vE+E+L, and 0.26—0.48% for other treatments. There were significantly fewer whiteheads in the check plots than in all other treatments ($F=8.46^{**}$)

During the vegetative phase there was a clear trend for more tillers/hill in the unprotected check treatment than in treatments where insecticides were effectively controlling *C. suppressalis*. In six counts between June 22 and July 26 the check plots showed a mean of 1.7(0.9-3.1) tillers/hill more than treatment *vE+E+L* ($N=39$; sign test significant at 5% level) This increase in tiller number was very close to the difference in injured tillers/hill between the two treatments (mean 1.7; range 0.8-2.7). At heading there was no difference between treatments in the numbers of panicles/hill.

Populations of hoppers were very low; *L. striatellus* and *N. cincticeps* peaked in July at eight and 28 individuals/100 sweeps respectively. No disease was observed in the experiment. Unlike 1973, leaf miners caused very little early damage.

There were no significant yield differences between treatments (Table 1).

DISCUSSION AND CONCLUSIONS

The four experiments reported in this paper are a start in the determination of economic thresholds for rice pests in Korea. The experiments were conducted under simulated farmers' field conditions; fairly large plots were used; usually many check or untreated plots were included which, unlike most conventional chemical control experiments, were not surrounded by heavily treated plots; a detailed record of pest populations was kept.

The main pests encountered were *C. suppressalis*, and *L. striatellus*, the latter transmitting serious stripe infection at one site. Of minor importance were *N. cincticeps*, *N. lugens*, *S. furcifera* and leaf miner. Apart from stripe, no other diseases were significant.

Economic thresholds for rice borers

Various economic thresholds, usually based on the proportion of injured or infested itllers, have been given for *C.suppressalis* in Japan. Threshold levels of 2-3% injured tillers (Koyama, 1973); and 3-9% infested tillers (Kobayashi, 1971) have been suggested for the first generation. For the second generation the same authors proposed 8-18% and 1.0-3.5% injured tillers respectively. In the Philippines, Pathak and Dyck(1972) have claimed that up to 10% dead hearts may be tolerated up to seven weeks after transplanting provided that the crop is subsequently protected by sprays.

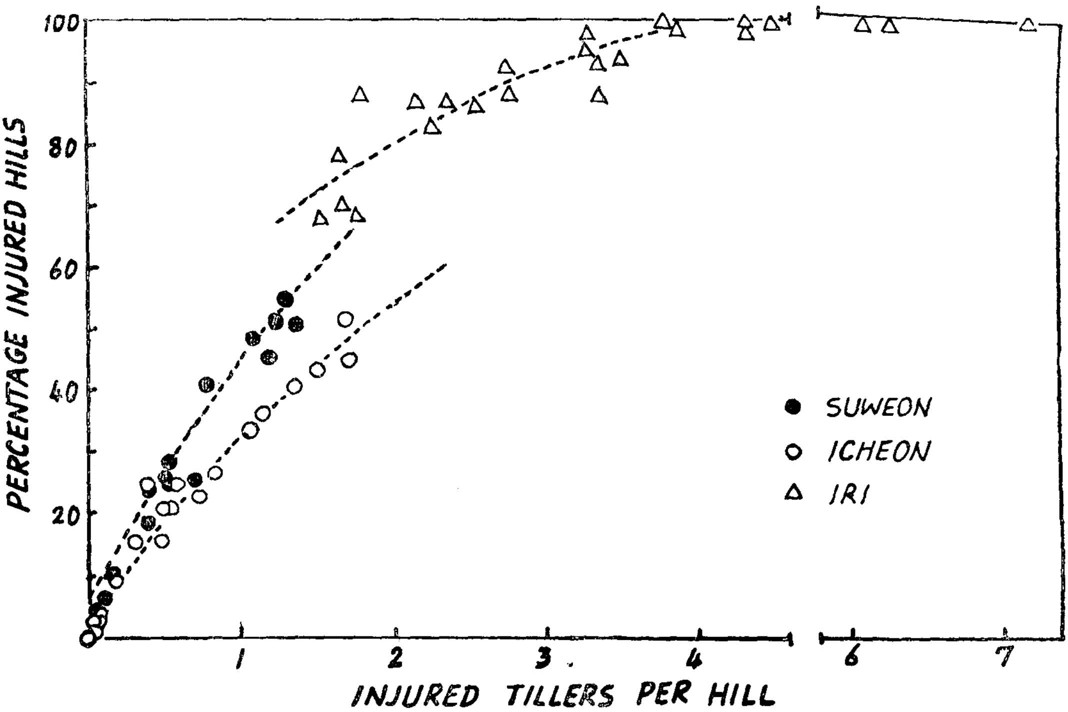
In the experiments carried out at Suweon and Icheon in 1973 the maximum number of injured tillers were 1.4 and 1.7 respectively (or approx. 8% injured tillers). At Icheon in 1974 the percentage injured tillers rose to 8.6% in the untreated plots during the first generation. These infestation levels produced no reduction in yield and were thus below the economic threshold. At Iri in 1973, where early transplanting was carried out according to offcial recommendations, the number of injured tillers/hill rose to 7.2. Because of the severe outbreak of stripe disease it was not possible to estimate how much borer damage contributed to the substantial yield loss but with the plants badly weakened by the disease there would probably have been little possibility of normal compensatory growth. Because of the low populations of *C. suppressalis* after th tillering stage in all experiments, no data on economi thresholds were obtained for the second generation.

Although the Tongil variety is believed to be mor susceptible to rice borers than most standard Korea japonica varieties, levels of 8.6% injured tillers durin the first generation produced no crop loss. Because u treated plots showed heavier tiller damage and high numbers of whiteheads than treated plots, vigoro compensatory growth is strongly indicated. At Iche in 1974, where the mechanizm of compensation w studied, more tillers were produced in plots with avier borer activity, this increase in tillers being direc proportional to the increased borer activity.

In the first generation there was a direct relations between percentage injured hills and the mean num of injured tillers/hill(Fig. 4). Torii (1971) reporte similar relationship for *C. suppressalis* in Japan, regression being useful for sequential sampling.

Economic thresholds for hoppers

Population densities of hopper pests were low the notable exception of *L. striatells* at Iri in 1 Stripe virus transmitted by this vector early in



. 4. Scatter diagram, showing the percentage of injured hills against the number of injured tillers/hill due to *hilo suppressalis* (Walk.) at experimental sites in Korea, 1973. Suweon $Y=43.495X^{738}$; Icheon $Y=34.345X^{7}$ i $Y=68.804X^{232}$.

on caused considerable crop loss. The vector was re in the seedbed and with ealry transplanting the lings were immediately exposed to population den- s of 1-2 individuals/hill. Vector populations had to 8 individuals/hill by early July. Disease sym- ts were observed before the first vector spray and the economic threshold in young plants is clearly below 1-2 hoppers/hill for this species.

cticide recommendations for Korea rice

Suweon and Icheon, situated north of the central growing area of Korea where the incidence of *C. ressalis* and hopper pests is more severe (Annony- , 1973), there was no difference in yield between receiving several applications of insecticide and remaining totally unprotected. Injury by *C. sup- alis* was made good by compensatory growth and ncidence of all other pests and diseases was negli- Mean yields for the experiments were high(5.2- ha) and close to those obtained by surrounding ers. Thus, official recommendations consisting of pesticide applications do not appear to be justified should be reconsidered.

rther south at Iri, stripe disease, and probably to ser extent *C. suppressalis*, markedly lowered the yield in 1973. The incidence of bot factors was increased by early transplanting, and the use of a susceptible variety further encouraged stripe. Applications to the seedbed and an early spray against the vector shortly after transplanting failed to check the disease. Despite a strict spray programme, other early transplanted japonica varieties became heavily infected during the same period at the nearby Crops Experiment Station. Yet the stripe-resistant Tongil variety remained healthy and yielded well-strongly suggesting that the use of resistant varieties is the most effective way of combating stripe.

Economic thresholds are not static: they fluctuate according to changes in cultivation practices, the introduction of new varieties, and even changes in the price structure of the crop. Thus this series of field experiments should be extended and repeated in different ecological areas on the main varieties grown in Korea.

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摘 要

主要 비 害虫의 經濟的 被害 水準을 決定하고 藥劑 散布 回數의 減小 可能性을 摸索하기 爲하여 水原 等 4個 地域의 農家 圃場 條件 下에서 本 硏究를 遂行하였다. 無散布區 慣行防除區 및 二·三의 慣行 防除를 修正한 處理區를 두었으며, 害虫 密度 및 病의 發生에 對해서도 詳細한 記錄을 行하였다.

i) 二化螟虫의 第1世代가 活發한 中部地方의 水原과 利川의 경우 數回 藥劑 散布區와 無散布區 사이의 收量의 差에 有意性이 없었으며, 平均 收量은 높아서 5.2~7.6t/ha 였다.

ii) 日本型 品種이나 多收性 品種인 統一 어느 品種에서도 收量의 減少를 認定할 수 없었던 故로 被害莖率이 8.6%까지 上昇한 第1世代 幼虫의 加害行爲는 經濟的 被害 水準 以下였다.

iii) 幼虫에 依한 被害는 被害莖이 代替되는 補償生長에 依해서 好轉된다는 證據가 얻어졌다. 二化螟虫의 第2世代 個體群은 언제나 낮았다.

iv) 水原과 利川에서 얻어진 結果를 볼때 現在의 慣行 藥劑 散布 回數 6~7回는 合當하지 않다.

v) 南部地方인 裡里의 경우 애멸구에 依한 줄무늬잎마름병이 初期에 大發生하여 이로 因해 實質的인 收量의 減少가 일어났다. 移秧 直後에 애멸구의 平均 密度는 株當 1~2마리였다. 二化螟虫도 이러한 收量의 減少에 影響을 주었을 可能性이 있다.

vi) 裡里에서 애멸구에 對해 數回의 藥劑 散布를 行하였으나 感受性 品種에서 急速하게 번져가는 줄무늬잎마름병을 막을 수 없었으며, 그 周邊 圃場의 抵抗性 品種인 統一은 比較的 影響을 받지 않았다.

vii) 끝동매미충, 벼멸구, 흰등멸구 및 벼잎굴파리는 重要性이 적은 害虫이다.

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