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Interaction between multiple pest problems and rice yields in Mekong delta of Vietnam

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ABSTRACT

To quantify the interaction between multiple pest injuries and rice yield, a collection of data based 200 rice hills was set up in a large field (1ha) of CLRRI production farm during two dry seasons :1998-1999 and 1999-2000. The primary results showed that infestation of pests was a combination of 2-5 injuries caused by leaf folder, yellow stem borer, rice blast, brown spot, narrow leaf spot, rice bug which were more abundance in milky and ripening stages of rice plants. The yield loss was significantly interacted by stem borer dead hearts, leaves with streaked <50% due to blast and grain damage by rice bugs in the ripening stage. The evidences of compensation of rice plants to the attacks by yellow stem borer and leaf folder also proved by the differences in the slope of the regression lines.

INTRODUCTION

A major objective of recent pest management research has been studied through the relationship between insect pest-disease intensity and yield losses for selected pest problems. While this research has greatly increased, our knowledge on the effect of pest loss relationships has resulted in much less effort being affected toward studying the yield reduction caused by infestations of combination of pest (Johnson 1990). Research on multiple-pest effects became a custom to deal with problem of rice yield losses. In many production systems, pest combination is common, so the decision making on the control of multiple pests is intertwined in the future. The objectives of a study on multiple-pest infestation usually can be divided into understanding and defining the combined effect of pest infestation on crop yield and providing recommendation or decision aids to manage multiple-pest problems. The distinction is made because the hypothesis and experimental designs for each differ. Yield production models may be to simply find that crop yield to expect attacked by single pest, or a model not simply may be caused by multiple pests. A simple model was introduced by Tchekmenev (198l), Walker (1960), Ho *et* al (1983), and Sanlp *et al* (1977). A multiple model was introduced by Abraham and Khosla (1967) through multifactoral regression. The other equations can be used are sigmoid relationship, logarithmic, and polynomial models. The form of equation depend on scatter diagram of data damage of pests to yield. The following questions, injury repeatability analysis, and experimental design provide a starting point for addressing gaps in pest-yield loss relations. The research must answers the following questions: (a) what fraction of the total number of observed hills sustains no disease or animal injuries and what is the yield difference between uninjured and injured hills?, (b) which single injury causes the largest and smallest yield loss?, (c) what is the relationship between injury severity and yield in each injury case?, (d) which combination of 2, 3, ?, n injuries causes the largest yield loss?, (e) is yield affected by the number of injuries ?

Insect pests and diseases are major threats to rice production in Mekong delta.

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Farmers have usually responded that they have worried about yield loss due to rice insects and diseases and over-estimated the damages on rice yield (Heong 1999). But nobody can quantify exactly how much of loosed rice because the relationship between damaged plants due to diseases and animal injuries is very little understood, especially in Vietnam. Schoenly (1998) recorded that counted populations of arthropod (GLH, BPH, WBPH) correlated poorly with grain yield on a hill basis. However, the effect of injuries on rice grain yield is still not clarified. Otherwise, research on multiple pest effects became a trend in studying rice yield loss. Thus it is necessary to study this theme under special conditions in Mekong delta.

OBJECTIVES

- To determine the multiple pests and yield loss relationships for understanding the combined effects of pest infestation on rice yield.
- To find out which single injury or combination causes the highest and lowest yield loss.
- To clarify the evidence of compensation in rice plants to any single injuries.

MATERIALS & METHODS

a. Location: Production farm of Cuulong Delta Rice Research Institute, Thoi thanh village, Omon district, Cantho Province.
b. Study timing: 1999 Dry season and 2000 Dry season
c. Experimental design
- Select 200 hills in 50 blocks (including 4 hills / block, each along a diagonal path, 25 on each side of path) within one field of 1 ha.
- After transplanting seedlings, mark the boundaries of each block (of 4 hills) with colored ribbon. The same blocks and hills within blocks were been visited in 5 times during the season at (1) seedling, (2) stem elongation, (3) booting, (4) milking, and (5) ripening stages.

d. Agronomic practices:
- Variety OM 1490 was sown on Nov.24, 1998 /Nov. 25, 1999 and transplanted on Dec.14, 1998 / Dec.15, 1999 in the spacing of 15 x 15 cm. Fertilizers were applied with the formula: 80 N-53 P_2O_5 -30 K_2O kg / ha, then N fertilizer was applied at 4 times: nursery stage, 7 days after transplanting (DAT), 21 DAT and 35 DAT, without pesticide. Rice plants were harvested on Feb.28, 1999 / March 2, 2000 with the total grain yield of 4.8 / 5.08 tons/ha.

e. Data collected: selected arthropod populations were counted, then analysing the coefficient correlation to grain yield / hill. Similarly, brown planthopper (BPH), white back blanthopper (WBPH), armyworm, caseworm, thrips etc. were implemented in the same way

The following injuries on a per hill were recorded from each of the 200 hills:
- % leaves <50% streaked/scraped = LWSL (brown spot, narrow brown leaf spot, leaf blast)
- % leaves >50% streaked/scraped = LWSM (narrow brown leaf spot, red striped disease)
- % tillers with galls = GM (gall midge)
- % folded leaves that have been scraped = FLS (leaf folders)
- % grains damaged = GRAINDAM (rice bugs)
- % stems cut at 45^o angle (rats)
- % dead hearts = DH (stem borer)
- % white heads = WH (stem borer)

* At harvest, gathering the 200 hills for yield estimation, separate seeds, and yield corrected at 14% moisture content, using a moisture tester and the following formula:

Adj. Grain Wt. per Hill = ((100 - MC)/86)*W
where: MC is moisture content (%) of the grains and W is the weight (g) of all harvested grains from one hill

- Additional 50 hills were collected from the same field that have not been studied and estimate yield.
- Data were loaded in Excel spreadsheets (as injuries per hill) using hills as rows (200 rows) and injuries as columns (max. 8 columns) with two beginning

columns labeling the hill (1, 2,?, 200) and block (1, 2,?, 50)

- Add "No. Injuries" at 11th column and total number of injuries sustained by each hill using COUNT formula.
- Injury data were regressed (X-axis) against yield (Y-axis) fitted with the best straight line (simple linear regression) based on the guidelines by K. Schoenly.

RESULTS & DISCUSSION

1. " No injury" by diseases or animals did not happen in thoroughly rice season, then yield difference between those hills "with injuries" was not distinguished from hills "without injuries". In 99 dry season, insect pests and diseases seriously attacked at the ripening stage (~ 4 injuries). However, it was severe at the booting and milky stages (3 injuries) in 2000 dry season (Fig. 1&2).

Figure1: Average injury number in rice stages
(CLRRI,DS 1998-1999)

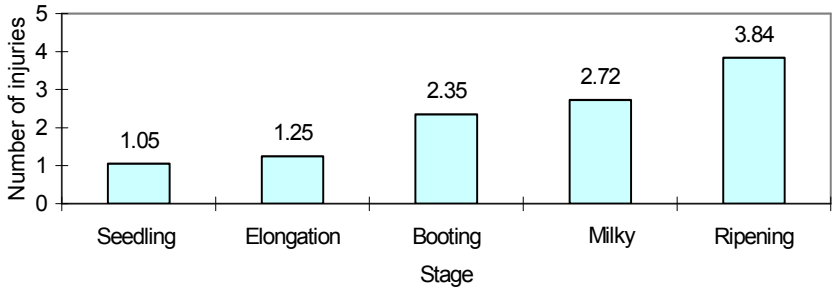
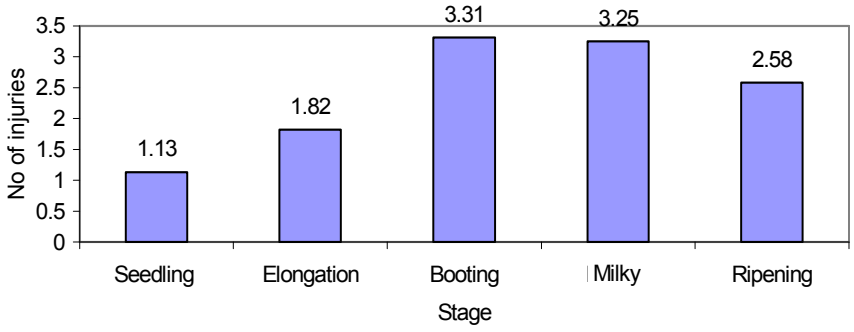


Figure 2: Average injury number in different rice stages
(CLRRI, 2000 dry season)



2. The number of injuries was increased gradually in five development stages of rice plants, from 1.05 to 3.84 in 1999 dry season. At ripening stage, a haft of rice hills sustained 4 injuries, ~ 30% of total hills sustained 3 injuries and ~ 20% of total hills sustained 5 injuries. But in 2000 dry season, maximum level of injuries was recorded at booting /milking stage and varied from 1.13 to 3.31 and two- third of rice hills sustained 3 injuries (Fig.3&4).

Figure 3:Frequency distribution of injuries
(CLRRI, 1999 DS)

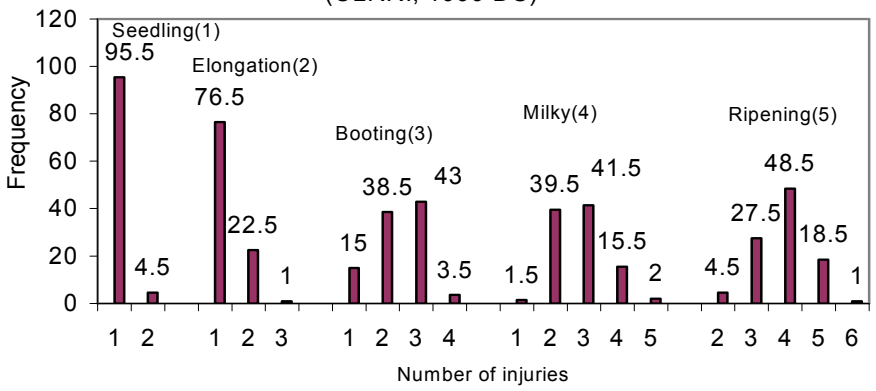
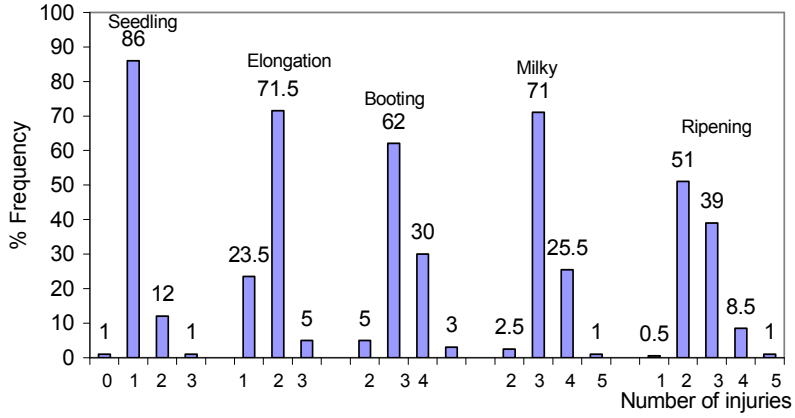


Figure 4: Frequency distribution of injuries
(CLRRI, 2000 DS)



The hills which was having 2 injury combinations were infected by leaves with streaked <50% =LWSL (combined brown spot, narrow brown leaf spot, leaf blast) and by leaves with streaked >50% = LSWM by narrow brown leaf spot and red stripped disease.The hills with 3 injury combinations were vulnerable to grain damage (GD), LWSL (usually are symtoms of brown spot, narrow brown leaf spot, leaf blast) and LSWM (composed by narrow brown leaf spot and red stripped disease). Usually, the hill which obtained the highest yield had only 3 injuries. Those with 4 injuries were linked by grain damage caused by rice bug, and leaves with streaked both <50% and >50% and folded leaves scrapted (FLS) caused by leaf folder. The lowest - yield hills usually were attacked by 5-6 injuries including grain damage (rice bug), dead hearts (DH) caused by yellow stem borer, folded leaves and leaves with streaked <50% and >50% (Fig. 5,6,7). It means that if the combination of injuries is much, the rice plant yield will be more damaged by these injuries.

Figure 5: Correlation between yields and 3 injuries

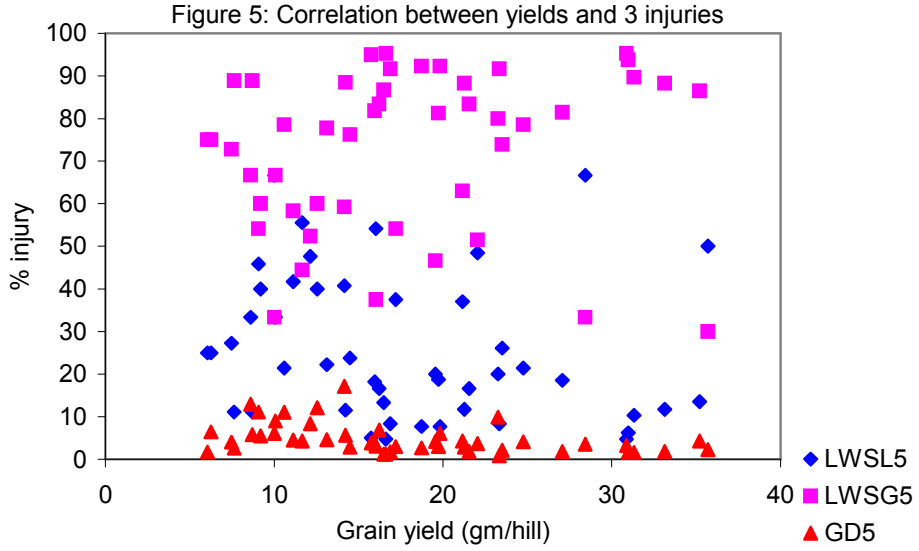


Figure 6: Correlation between yields and 4 injuries

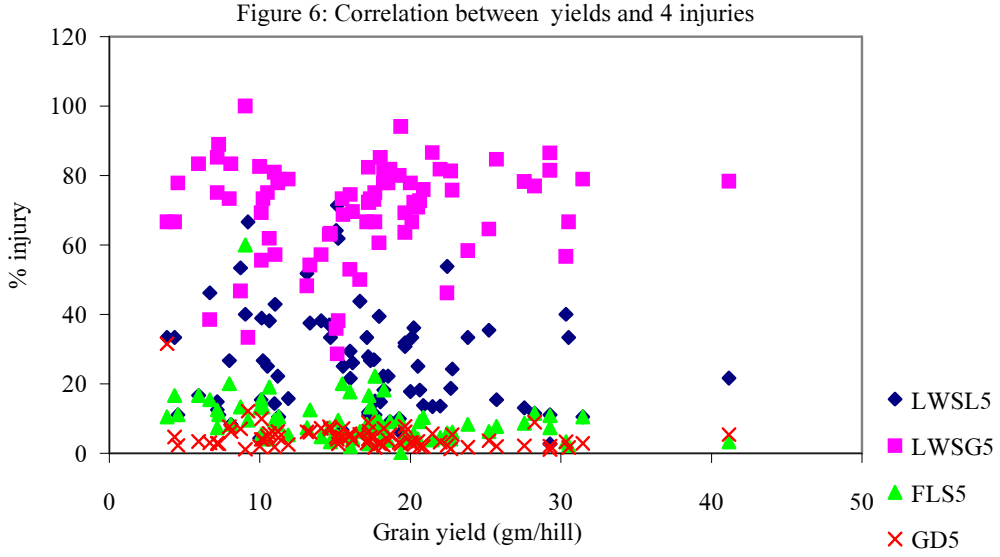
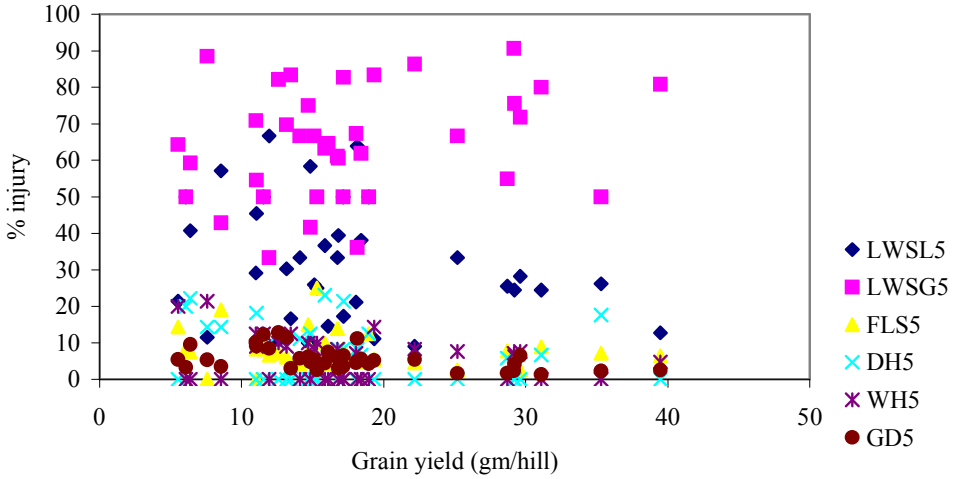


Figure 7: Correlation between yields and 6 injuries



3. The rice yield was relatively affected by number of injuries. That means yield per hill is a simple function of the injury number. The trend line of yield came down slightly with the injury number, especially in 99 DS (Fig. 8, 9, 10). The injury percentages varied from 1 to 72% and the most severe damages caused by LWSM (72%), LWSL (64%) at the milking and ripening stages were noticed with the causal factors as blast, RSD, Brown spot... FLS caused by leaf folder was the most serious at booting stage in 2000 (23%). However, these attacks were not serious as compared to dead heart (DH), white head (WH) by yellow stem borer and grain damage by rice bug which had low severities (1-10%). The injury levels were significantly different between two years: 1999 and 2000, except the LWSL5, LWSM4, GM4, YIELD and ShB (sheath blight). The highest injury was LWSM at ripening stage. The next was LWLS at seedling and elongation stages. The attack of white head (WH) was recorded as lowest injury (Table 1,2,3).

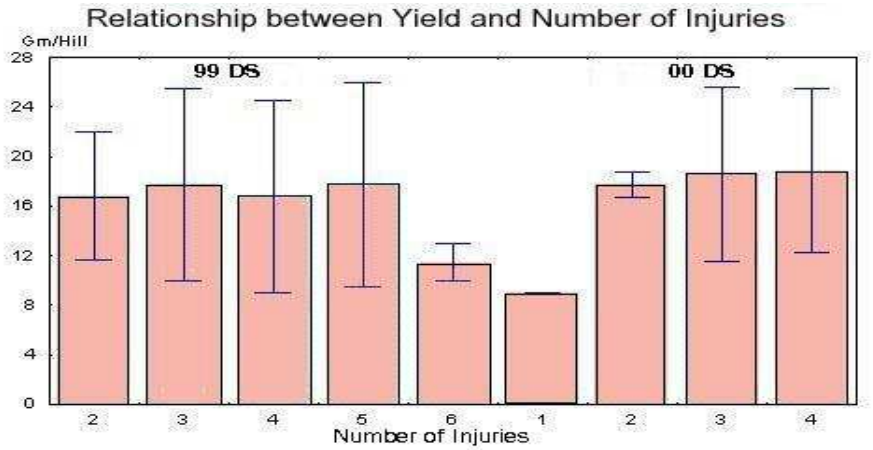
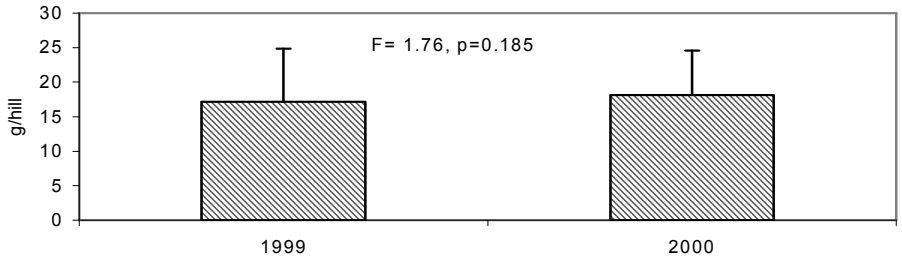


Figure 8: Relationship between yield and number of injuries

4. The rice yields did not differ between two years (1999-2000) and negatively related to injuries at the milky (4) and ripening stages (5). The yield loss was interacted with severity of injury ranking as followed (Table 4)
   - Grain damages (GD) affected by rice bugs with R=-0.236**, y=18.805 - $0.489x_1$
   - Dead hearts (DH) caused by stem borer with R=-0.171*, y = 18.141 - $0.159x_2$
   - Leaves with streaked <50% (LWSL) infected by blast in 2000'year
   - with R = -0.176**, y =19.93 - $0.086x_3$
   - And for all about y = 20.712 - $0.3662x_1$ - $0.1135x_2$ - $0.0697x_3$

Figure 9: Grain yield of two years



5. Only leaves with streaked >50% (LWSM) caused by leaf diseases such as narrow brown spot, red striped disease (RSD), brown spot (BRSPOT), bacterial leaf blight (BLB), sheath blight (ShB), discoloration and folded leaf scrapted (FLS) were not affected to yield loss.

   WH = white head, BLB=baterial leaf blight, DH=dead heart, LWSM = leaves with streaked more than 50%, FLS = folded leaf scrapted, BRSPOT = brown spot, RSD = red stripped disease, RSD = red stripped disease, SHB = sheath blight, DISCOLOR = discoloration, WHD = white head by disease, GM =gall midge, LWSL = leaves with less than 50%, GRAINDAM=grain damage. Score 1=seedling stage, 2 = elongationstage, 3 = booting stage, 4 = milky stage, 5 = ripening stage

Figure 10: Average Levels of injuries

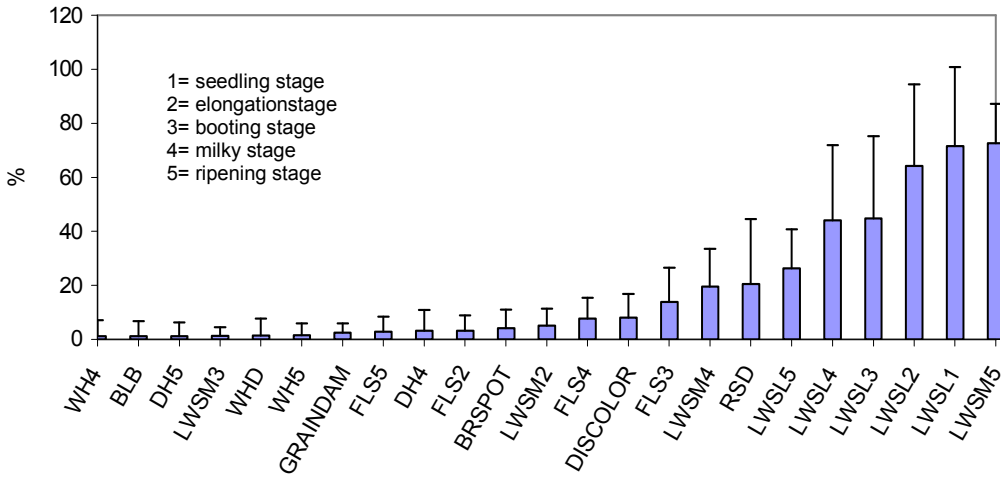


Table 1:The difference of injuries between two years

Variables	1999	2000	F	P
LWSL1	84.11	58.87	91.05	0.000
LWSM5	71.31	73.86	3.09	0.08
LWSL2	69.00	59.45	10.32	0.000
LWSL4	41.01	47.16	4.91	0.030
LWSL3	27.48	61.99	187.59	0.000
LWSL5	26.51	25.93	0.16	0.69
LWSM4	20.35	18.6	1.55	0.21
YIELD	17.17	18.11	1.76	0.185
DH4	5.82	0.52	54.68	0.000
FLS5	5.54	0.07	126.11	0.000
GRAINDAM(RB)	4.77	0.00	378.47	0.000
FLS3	4.23	23.41	549.2	0.000
LWSM3	2.61	0	85.07	0.000
DH5	2.41	0.00	24.67	0.000
LWSM2	2.24	7.81	95.51	0.000
WH5	1.91	1.13	3.19	0.07
FLS4	1.34	13.97	819.32	0.000
DH3	1.2	0.39	8.7	0.000
GM3	0.42	1.20	8.4	0.000
WH4	0.41	1.76	5.19	0.02
GM4	0.13	0.12	0.00	0.16
FLS2	0	6.46	197.52	0.000
WHD	0.0	2.9	22.83	0.000
DISCOLOR	0.00	16.1	1998.0	0.000
BROWN SPOT	0.00	8.18	221.85	0.000
RSD	0.00	40.96	1071.8	0.000
SHB	0.00	0.10	1.00	0.32
BLB	0.00	2.37	19.31	0.000

WH=white head, BLB=baterial leaf blight, DH=dead heart, LWSM=leaves with streaked more than 50%, FLS=folded leaf scrapted, BRSPOT=brown spot, RSD=red stripped disease, RSD= red stripped disease, SHB = sheath blight, DISCOLOR=discoloration, WHD=white head by disease, GM =gall midge, LWSL=leaves with less than 50%, GRAINDAM=grain damage 1=seedling stage, 2=elongationstage, 3=booting stage,4=milky stage, 5=ripening stage

Table 2: Correlation between yield and injuries in two years

Injury	Target pest	R	p
LWSL5	Blast	-0.176	0.000**
GRAINDAM	Rice bug	-0.236	0.000**
DH4	Dead heart (Stem borer)	-0.171	0.001*
LWSM4	Ragged Stunt Disease	0.149	0.003
DH5		-0.150	0.003
LWSL4		0.146	0.004
FLS5	Leaf folder	-0.144	0.004
LWSM2		-0.132	0.008
LWSM5		0.132	0.008

Table 2: continue

RSD		0.093	0.062
DH3		-0.093	0.063
LWSL3		0.085	0.088
WH4		-0.078	0.119
BLB	Bacterial leaf Blight	0.071	0.154
LWSL2		0.066	0.186
GM4	Gall midge	-0.060	0.230
LWSM3		-0.053	0.294
FLS4		0.049	0.326
WH5	White Head	-0.042	0.408
FLS2		-0.040	0.423
WHD	White Head by diseases	-0.036	0.469
LWSL1		0.031	0.531
BLAST		0.029	0.564
GM3		-0.028	0.573
FLS3		-0.012	0.804
BRSPOT	Brown spot	-0.010	0.839
SHB	Sheath Blight	0.003	0.951
DISCOLOR	Grain discoloration	0.002	0.966

WH=white head, BLB=baterial leaf blight, DH=dead heart, LWSM=leaves with streaked more than 50%, FLS=folded leaf scrapted, BRSPOT=brown spot, RSD=red stripped disease, RSD = red stripped disease, SHB = sheath blight, DISCOLOR = discoloration, WHD = white head by disease, GM = gall midge, LWSL = leaves with less than 50%, GRAINDAM = grain damage 1 = seedling stage, 2 = elongationstage, 3 = booting stage,4=milky stage, 5=ripening stage

Table 3: Relationship between yield and rice disease index at ripening stage (CLRRI, 2000 DS)

Yield (gm/hill) v.s. X	Correlation coefficient	Linear regression
I. All Hills	**r**	**Y**
- White head due to diseases (%)	-0.0827ns	Y=18.289-0.062X
- Brown spot disease index (%)	-0.0967ns	Y=18.765-0.081X
- Rice Blast disease index (%)	+0.0294ns	Y=18.667+0.343X
- Red Striped Disease index (%)	+0.1049ns	Y=16.48+0.04X
- Bacterial Leaf Blight index (%)	+0.0940ns	Y=17.926+0.077X
- Sheath Blight disease index (%)	-0.0003ns	Y=18.109-0.002X
II. Hills With injury		
- White head due to diseases (%)	-0.3195ns	Y=20.95-0.157X
- Brown spot disease index (%)	-0.1459*	Y=19.146-0.122X
- Rice Blast disease index (%)	-0.1300ns	Y=22.037-1.169X
- Red Striped Disease index (%)	+0.1399*	Y=15.837+0.653X
- Bacterial Leaf Blight index (%)	+0.4414*	Y=15.584+0.161X

Table 4: Regression analysis between yield and injuries

PESTS	Coefficient	β	R^2	F	p
DH4	18.141	-0.159	0.0291	11.96	0.0006
LWSL5	19.930	-0.086	0.0310	12.51	0.0004
GRAINDAM	18.805	-0.489	0.0555	22.41	0.0000
All of above	20.712	-0.1135 -0.0697 -0.3662	0.0791	12.31	0.0000

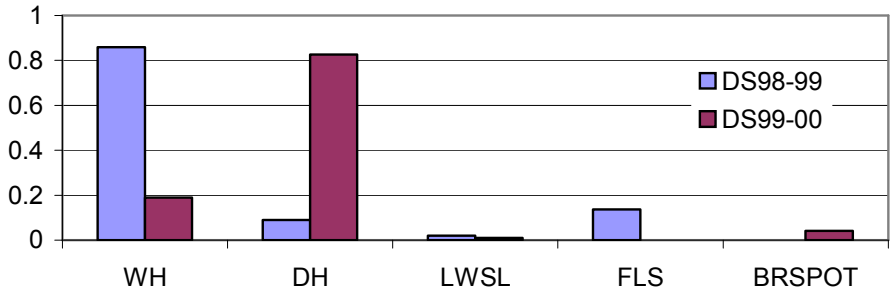
6. Some evidences shown that injuries as dead heart, white head caused by stem borer and folded leaves scrapted by leaf folder promoted compensation of rice plants and one case of brown spot disease. Expression of this compensation was expected by difference of slop of regression lines as compared to all hills and injury hills. For example the difference of DH, WH, LWSL in 99 DS was 0.09, 0.732, 0.02, respectively (Table5, fig.10-16). The data showed that the larger the difference is the greater the compensation.

Table 5:Relation between rice yield and injuries at ripening stage

Yield (gm/hill) v.s. X	1999 Dry Season		2000 Dry Season	
I. All Hills	Correlation coefficient **r**	Linear regression **Y**	Correlation coefficient **R**	Linear regression **Y**
- Grain damaged (%)	-0.347**	**Y**=20.826-0.767**X**	-0.223*	Y=22.664-0.285X
- Dead heart (DH) (%)	-0.181**	**Y**=17.657-0.203**X**	-0.041ns	Y=18.706-0.109X
- Folded leaves scraped FLS (%)	-0.170*	**Y**=18.218-0.190**X**	+0.171*	Y=17.431+0.238X
- Number of injuries	-0.020 ns	**Y**=17.889-0.188**X**	-0.02ns	Y=17.889-0.187X
- White head (WH) (%)	-0.071ns	**Y**=17.392-0.117**X**	-0.134ns	Y=18.286-0.203X
- Leaves with streaked <50% (%)	-0.204**	**Y**=19.381-0.085**X**	-0.107ns	Y=19.494-0.046X
- Leaves with streaked >50% (%)	+0.155*	**Y**=12.545+0.650**X**	+0.103ns	Y=15.09+0.043X
- Leaves with Gall(%)			+0.057ns	Y=18.04+0.246X
- Stem cut at 45^o (by Rat)			-0.118ns	Y=18.212-0.402X
II. Hills with injuries				
- White head (WH) (%)	-0.631**	**Y**=28.820-0.976**X**	-0.8817**	Y=22.383-0.393X
- Folded leaves scraped (%)	-0.292**	**Y**=20.151-0.327**X**	-0.006ns	Y=20.06-0.01X
- Dead heart (DH) (%)	-0.370*	**Y**=19.619-0.293**X**	-0.583*	Y=26.576-0.935X
- Leaves with streaked <50% (%)	-0.231**	**Y**=20.134-0.105**X**	-0.129ns	Y=19.888-0.057X
- Leaves with Gall(%)			-0.205ns	Y=22.758-0.327X
- Stem cut at 45^o (by Rat)			-0.744ns	Y=37.885-1.799X

ns : non significantly different , * significantly different at 5% level
** significantly different at 1% level

Figure 11: Difference in regression slope of lines



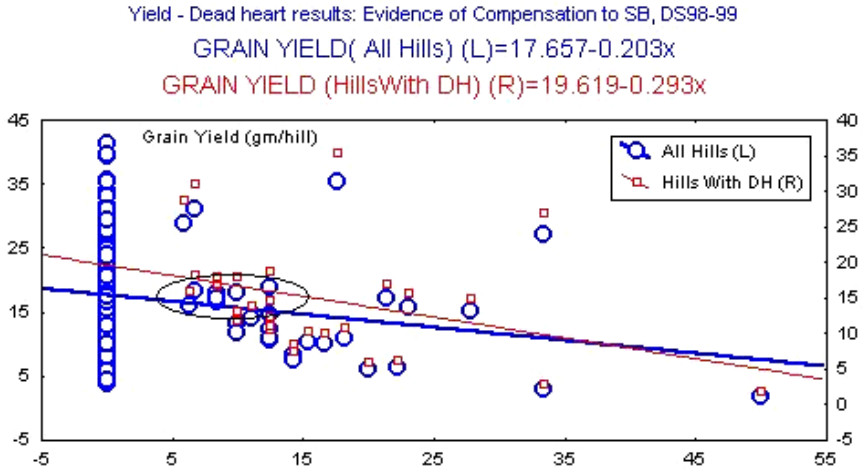


Figure 12

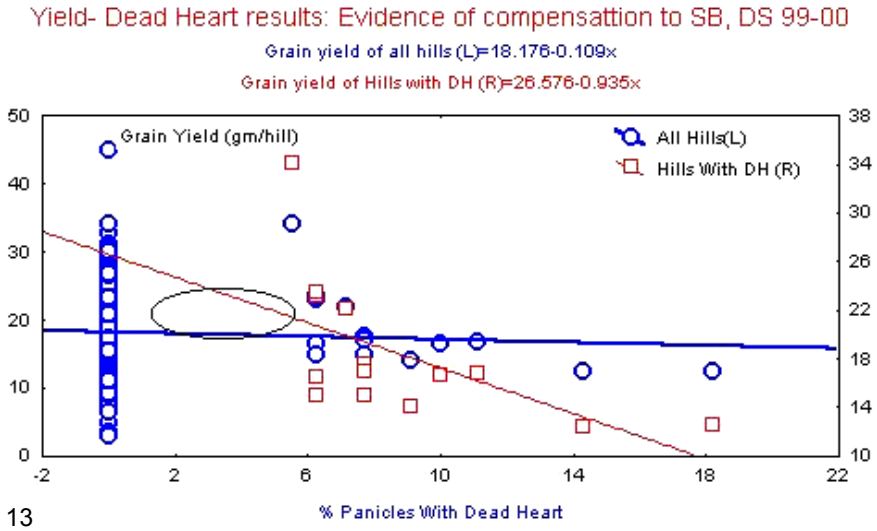


Figure 13

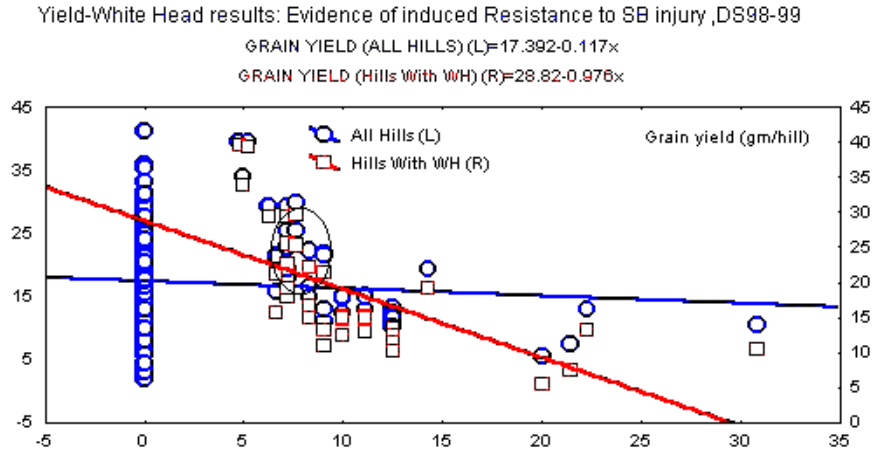


Figure 14

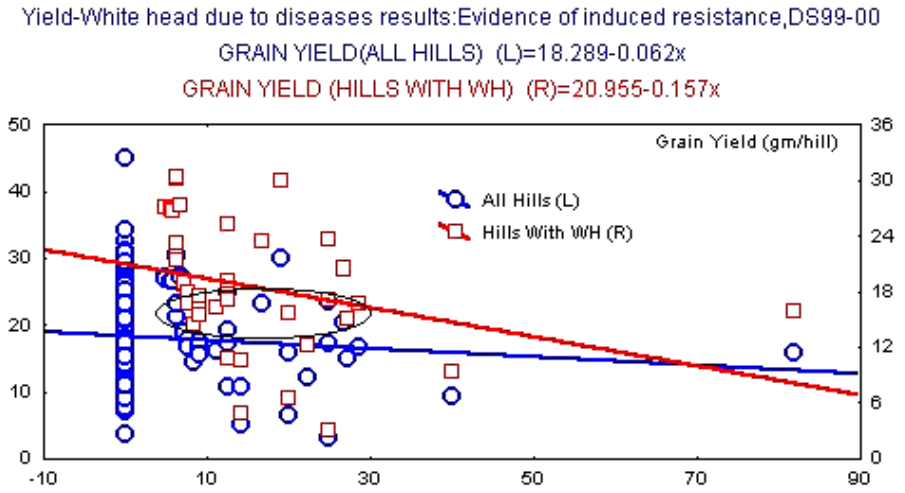


Figure 15

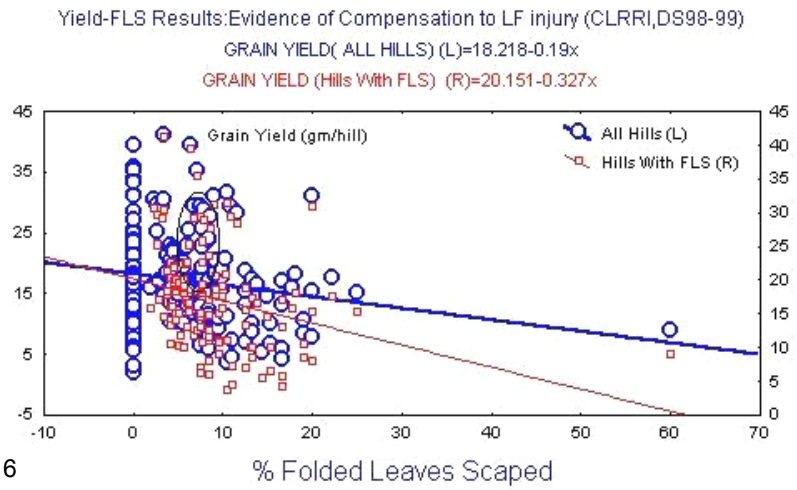


Figure 16

CONCLUSIONS

- Damage of insect pests on rice was a complex of 2-5 injuries, there was no any healthy plant during two dry seasons (1999-2000). Most of injuries was abundance in milking and ripening stages which was having frequency of 40-50% for each combination.
- Leaves with streaked lesser than 50% (LWSL) infected by brown spot, narrow leaf spot developed more at seedling and elongation stages with the incidences of 64-71%, but rice yields were not losed due to the compensate capacity.
- However, LWSL damaged by blast occurred at booting and milking stages related to yield loss although its incidences were not too high because OM1490 variety was susceptible to blast. Leaves with streaked more than 50% (LWSM) caused by Red Stripped Disease, Sheath Blight attacked the rice plants at the milky and ripening stages with very high percentage, but it was not related to yields. Grain yields / hill were not different during two seasons (1999 /2000)
- The rice grain yields were negatively related to injuries at the milky and ripening stage and the yield loss was interacted with severity of multiple injury ranking as followed:
  - Grain damages by rice bugs in the ripening stage
  - Dead hearts by stem borer at milky stage
  - Leaves with streaked <50% by blast disease at ripening stage.
- There were evidences of compensation of rice plants to the infestation of yellow stem borer and leaf folder.

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SUMMARY IN VIETNAMESE

Tương tác giữa sâu bệnh hại và năng suất lúa tại Đồng bằng sông Cửu long

Để định lượng sự tương tác giữa phối hợp nhiều sâu bệnh hại đến năng suất lúa, dữ liệu về các chỉ tiêu dịch và năng suất của 200 bụi lúa đã được thu thập trên cánh đồng rộng 1 ha trong thời gian 2 mùa khô Đông xuân 1998-1999 và Đông Xuân 1999-2000.

Kết quả bước đầu cho thấy sâu bệnh hại lúa là sự tác động của từ 2 đến 5 loài dịch hại cùng lúc của sâu cuốn lá, sâu đục thân, cháy lá, đốm nâu, gạch nâu, bọ xít..thường gây hại nặng trong thời kỳ chín sắp thu hoạch. Sự thất thoát năng suất có ý nghĩa thống kê là do chết đọt bởi sâu đục thân, cháy lá và hạt bị bọ xít chích hút. Nghiên cứu nầy cũng ghi nhận có hiện tượng bù trừ của cây lúa khi có sự tấn công của sâu đục thân và sâu cuốn lá.