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PEST PROFILES IN AN IMPROVEMENT OF FARMERS' MANAGEMENT PRACTICES (SSNM VS FFP) OF IRRIGATED RICE SYSTEM OF TROPICAL ASIA

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ABSTRACT

Data on pests and diseases were collected from 606 farmer's fields of the Reversing Trend of Declining Productivity (RTDP) Project during the 1998 and 1999 wet seasons and the 1999 dry season. The surveys were conducted on sites in China, Vietnam, the Philippines, Indonesia and India. Comparisons were made for plots with Site Specific Nutrient Mangement (SSNM) and Farmer's Field Practices (FFP). Pest profiles were rather different due to its high incidence of key pests in some seasons. IN1 was a dominant pest profile with relatively high incidence of bacterial leaf blight (BB), brown spot (BS), red stripe (RS), sheath blight (SHB), grain discoloration (GD), whorl maggot(WM), leaf folder (LF) and dead heart (DH), but high yield (5.5 t ha^{-1}). It included Vietnam, the Philippines, China and South India. IN2 was found in the Red River delta of Vietnam and was associated with highest yield (5.8 t ha^{-1}) and fewer insect pests but high incidence of sheath blight and bacterial leaf blight. IN3 belonged to Indonesia and the Philippines, and IN4 to Indonesia (1st and 2nd season).IN3 and IN4 were associated with high incidence of bacterial leaf blight, narrow brown spot (NBS), red stripe, sheath blight, grain discoloration, stem rot, leaf folder and dead heart and relatively low mean yield (4.6; 4.4 t ha^{-1}, respectively). IN5 occurred in China (2nd season). Correspondence analysis provided information on association of insect pests and diseases with medium (3.7 t ha^{-1}) to high yield (> 6.7 t ha^{-1}) with low (50-80 kg N ha^{-1}) to medium (80-120 kg N ha^{-1}) and high N input (150 kg N ha^{-1}). Stepwise multiple regression analysis indicated LF and SB are most N dependent variables among injuries. SB, GD, BS and RS are also major yield reducing factors on farms. Mean yields across sites was 5.1 t ha^{-1} rather higher with better nutrient management than in FFP farms compared to estimated yield (4.12 t ha^{-1}) of other fields across the region.

Key words: cluster analysis, correspondence analysis, farmers' field practice, injury profile, principal component analysis

INTRODUCTION

Many areas covered by rainfed-lowland rice and floating and deep water rice have been transformed to irrigated systems. However, the consequences of change to intensive rice systems has not yet been thoroughly assessed in terms of pest management.

Pest management has regularly faced outbreaks of brown plant hopper, rice blast, sheath blight and red stripe in southeast Asia (Mew et al. 2001). Pesticide application has become a common practice to protect high yielding crops, but most are unnecessary and misused (Heong et al. 1995a; Du and Savary 1997). Farmer's field research (FFR) with no early spaying pesticides for control of rice leaf folder and so protect natural enemies in the Mekong Delta of Vietnam (Heong et al 1995b) has led to a significant reduction of pesticides use. Several hypothesis for improvement of rice yield under different production situations have considered the possible effect of nutrition on pest damage (Huber,1980; Marschner,1995; Hardter1996). Nitrogen is the most common yield-limiting nutrient in rice cropping systems (Mikkelsen 1987; Cassman et al. 1996), and is also difficult nutrient to manage. On farms studied for declining productivity a Site-Specific Nutrient Management model (SSNM) was promoted for organized groups of farmers of several Asian countries. It provided a realistic approach for feeding rice with nutrients as needed (Buresh and Witt, 2002). Analysis of pest and disease injury with such field crop practices will provide important information for understanding the system for which improved of rice pest management to be designed (Teng and Heong 1988; IRRI 1990)

MATERIALS AND METHODS

Surveys were conducted in three continuous seasons, the 1998, 1999 wet seasons, and the 1999 dry season. Pest monitoring of rice crops was done at 'Reversing Trend of Declining Productivity' project sites in P.R. China (Jinhua), India (Thanjavur, Adthurai and Pantnagar), Indonesia (Sukamandi), Philippines (Munoz), and Vietnam (Mekong and Red River Deltas). Pest monitoring was conducted on about 160 farms in total. Except for the P.R. China site each country site monitored 16-22 farms located within a 15-30 km radius around the collaborating research institute. There were five field plot treatments including zero fertiliser (0 NPK), NP, NK, NPK (SSNM) and NPK (Farmer's Field Practice, FFP). In FFP field plots, farmers compared a balanced-NPK fertilizer with SSNM field plots where N rate application was based on weekly cholorophyll meter or SPAD meter readings used to determine need-based N fertilization (Peng et al. 1996). Pest and disease injuries over three seasons were recorded for all five field plot treatments at the Mekong (Vietnam), Thanjavur (India), and Andurai (India) sites and for SSNM and FFP treatments at the other sites. A total of 1067 field plots were observed of which 606 had both SSNM and FFP records. SSNM vs FFP plots ranged from 300 to 1000 m^2 in area, within which 200 m^2 was used for pest monitoring. The quantitative information of pest injuries followed the survey protocol of Savary et al. (1996). Assessments of diseases and insect pests were done for 12 hills in transplanted rice or 12 quadrats (10 x 10 cm) in direct seeded rice. Hills or quadrates were selected at equal distance along a diagonal transect in each plot for every monitoring visit.

Four groups of data were collected at the individual field level. A first variable was the two categories of SSNM and FFP as homogenous representative types of rice field crop practice. Previous experiences at RTDP sites indicated that quantification of injuries whether generic or site-specific to N rates and yield variation needed to be tested. The next two categories were the levels of N fertilizer (FE) applied and the season (SE) when the survey was conducted in order to quantify the occurrence of pests over time. A third group of variables was diseases and insect injuries. Disease variables were BB (bacterial leaf blight), LB (leaf blast), BS (Brown spot), NBS (Narrow brown spot), RS (Red stripe), SHB (sheath blight), SHR (sheath rot), STR (stem rot), PB (panicle blast), and GD (grain discoloration). Insect damage were classed as WM (whorl maggot), LF (leaf folder), AW (army worm), DH (dead-heart) and RB (rice bug). The last variable was grain yield (Y), which was measured by RTDP group.

Analyses of data were based on 606 field plots of SSNM and FFP for all sites. Although a large number of diseases and insects were observed, some of those not frequently recorded were not included. Analyses were conducted to determine the linkage between N rates and insect and disease injuries, and whether actual yield variation could be explained by these injuries.

There were two analytical approaches (Savary et al. 1997a). The first emphasized the qualitative nature of cropping practices and seasons of investigation. The second was quantitative, mostly rate of N apply and injury variables, aiming to explain yield variation by injury variables.

In the first approach, the data collected were analyzed in four steps (Savary et al. 1995). At first quantitative variables were categorized into classes, then the number of classes was reduced, for example, most injuries are represented by three to five classes. N fertilizer rates were in four classes and grain yield five classes. They became ordinal, qualitative variables while cropping practices were replaced by two classes (FFP and SSNM). Seasons of pest surveys remained cardinal, qualitative variables. Numerical boundaries and classes were created and relationships among variables characterized.

The correspondence analysis used (Greenacre 1984) is a non-parametric, multivariate techniques which can synthesize data from one or several contingency tables so that they can be mapped on a summarized representation of a multivariate data set (Savary et al. 1997b).

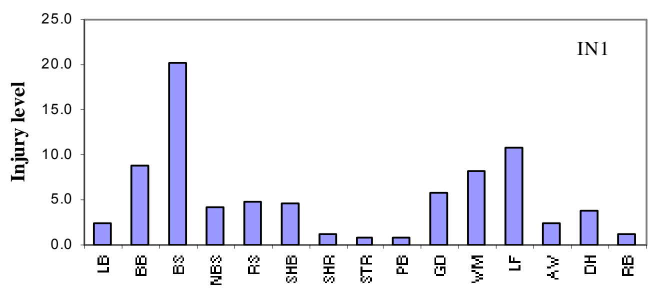
The second approach was a principal component analysis applied to quantitative variables of N fertilizer rates and injuries, but not grain yield. Considering N rates as an important yield limiting factor and injuries due to pathogens and insects as yield reducing factors, this analysis was used to identify the mass components of variables among factors generated.

Lastly was a stepwise multiple regression analysis of the same data set using actual yield (Y_{ac}) as dependent variables to identify whether yield variation can be explained by yield reducing variables, and whether using N fertilizer rates (F_r) as dependent variables to determine different levels of N used would indirectly affect injuries variables.

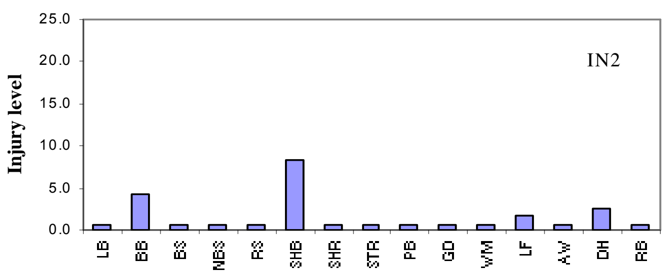
III. RESULTS

Pest injuries in SSNM and FFP varied across sites and seasons. The mean values of the variables showed that some injuries had a high incidence during all three seasons (BS, RS, SHB, GD), but the rest were of medium and low incidence. The amount of N applied in SSNM was higher than in the FFP, and the mean yield was higher. Average yield of rice crop practice plots (SSNM, FFP) was 5.12 t ha^{-1}, and N applied was 115.8 kg ha^{-1}.

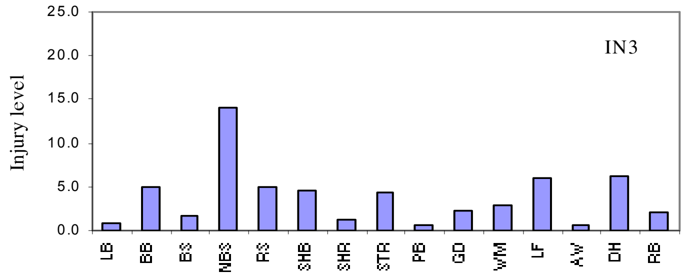
Cluster analysis of injury profiles across sites and seasons indicated five groups of injury profiles as listed in the abstract. Pest profiles shared a similar pattern in three seasons (1998 and 1999 wet seasons and 1999 dry season) while in China and the Philippines there were similar pest profiles of wet season (Figure 1).



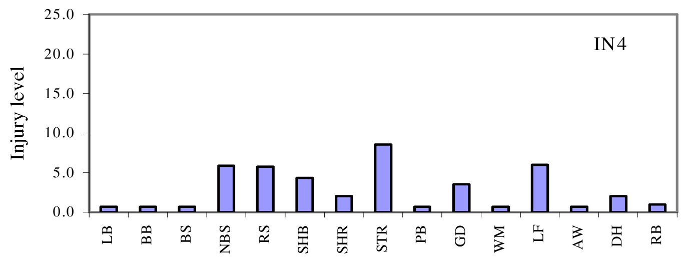
Mekong delta, Red river delta Vietnam
Munoz, Philippines
Jinhua, China
Thanjavur, India
Mean yield: 5.5 tons ha^{-1}
N fertilizer : 114,6 kg ha^{-1}



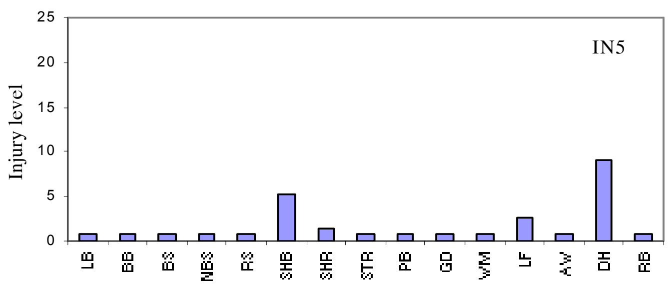
Red river delta, Vietnam
Mean yield: 5.8 tons ha^{-1}
N fertilizer : 96,9 kg ha^{-1}



Sukamandi, Indonesia
Munoz, Philippines
Mean yield: 4.6 tons ha $^{-1}$
N fertilizer : 107,8 kg ha^{-1}



Sukamandi, Indonesia
Mean yield: 4.4 tons ha $^{-1}$
N fertilizer : 125,3 kg ha^{-1}



Jinhua, China
Mean yield: 5.0 tons ha $^{-1}$
N fertilizer : 142,5 kg ha^{-1}

Figure 1: Injury levels in nutrient site-specific rice crops across six countries in 3 seasons (98 Wet, 98-99 Dry and 99 wet), 5 classes of injury were determined (IN1, IN2, IN3, IN4, IN5). The horizontal axis indicates different levels among 15 injuries, LB: leaf blast; BB: bacterial leaf blight; BS: Brow spot; NBS: narrow brow spot; RS: red stripe; SHB: sheath blight; SHR sheath rot; STR: stem rot; PB: panicle blast; GD: grain discoloration; WM: whorl maggot; AW: army worm; LF: leaf folder; DH: dead heart; RB: rice bug.

Chi square tests between yield variation and injuries indicated that that there were only two cases, SHR and RB, for which the null hypothesis was accepted. For other injuries, the null hypothesis of independence of actual yield and injuries was rejected (LB, BB, BS, NBS, RS, SHB, STR, PB, GD, WM, LF, AW and DH).

Chi square tests of linkages between N rates applied and injury profiles indicated four cases in which null hypothesis was accepted, for LB, PB, SHR and DH. The severity of other injuries was associated with N fertilizer application (BB, BS, NBS, RS, SHB, STR, GD, WM, LF, AW, RB).

In the simple correspondence analysis yield classes were used as additional classes so that variation of yield levels could be explained in relation to farmers' field crop practices, seasons and N rates [(SSNM, FFP) x IN (diseases, insects)], [SE x IN (diseases, insects)] and [FE x IN (diseases, insects.

Analysis shows the first two axes as they account for 35.6 and 21.7% of total inertia. In the first axis, the injury levels of RS are one of three levels of classes with coordinates (-0.099, -0.122 and 0.516) of RS1, RS2 and RS3 respectively. RS1 and RS3 have the largest contribution to axes one (3.6 and 20.6, respectively), and the movement in a positive direction along axis one corresponds to increasing levels of RS injuries. SHB was observed with a similar pattern of injury, coordinates of SHB are 0.040, -0.122 and 0.516 for three levels of SHB1, SHB2 and SHB3, respectively. SHB is well accounted for by this axes, levels of SHB also have a large contribution to the axes (0.4, 0.0, and 2.0 for SHB1, SHB2 and SHB3, respectively). Similar patterns are observed in the cases for BB, BS, NBS, STR, GD and WM. Movement along axis one, decreasing levels of injury pattern was observed in DH (coordinates, 0.141, -0.167, -0.015 for DH1, DH2 and DH3, respectively). DH contributes large values to axis one (6.7 and 2.2 for DH1 and DH2, respectively). The inertia accounted by first was 35,6 %. It represents for increasing levels of injuries (SB, BB, BS, NBS, STR, GD, and WM) and decreasing levels of DH injury.

Increasing levels of RS, BS, NBS, BB, LF, and AW were found along the second axis. The contribution of levels of BB (0.2, 0.4, and 3.8); RS (1.8, 3.3, and 3.6) and LF (0.5, 0.5, and 4.4) was prominent. A decreasing level of SB, GD, and DH along the second axis was observed in which levels of SB, GD and DH had large values (5.0, 2.2 and 1.0; 7.1, 8.4 and 0.3; 14.8, 0.2, and 3.8, respectively). The inertia accounted for by the second axis was 21.7 %. The total contribution of the two axes was 57.3 % and gives a good indication of the levels of injuries in the combination of the two axes. Levels of injury classes are indicated and its association with N rate in Figure 2. Association of injury classes and yields (Y) are indicated in Figure 3.

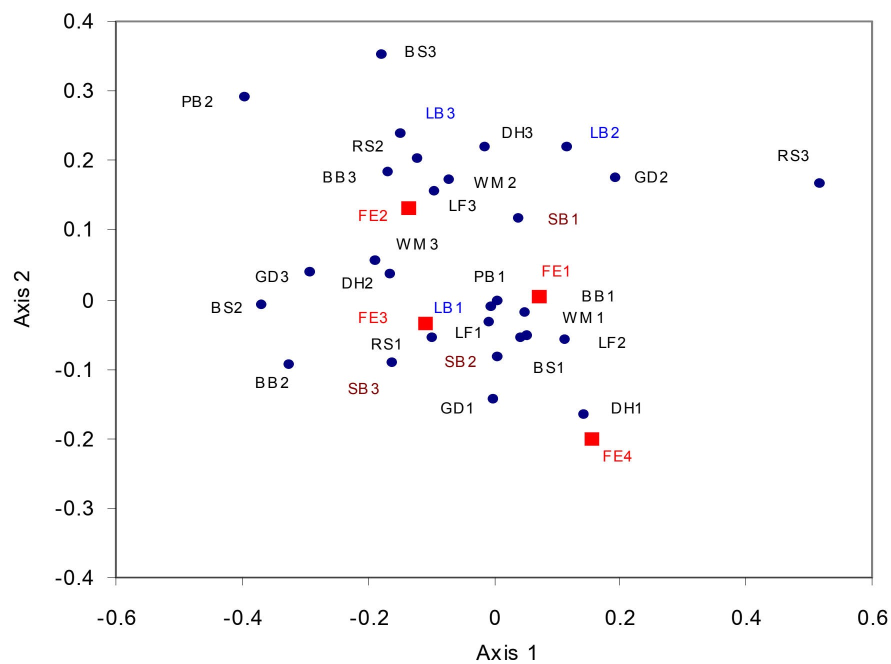


Figure 2. Correspondence analysis between fertilizer application and pest injuries. Axis 1 and 2 are represented horizontally and vertically, respectively, respectively. The axes are defined using classes of categorization. The successive classes are indicated relationship between levels of fertilizer applied in field plots and different of pest injuries in six sites of tropical Asia

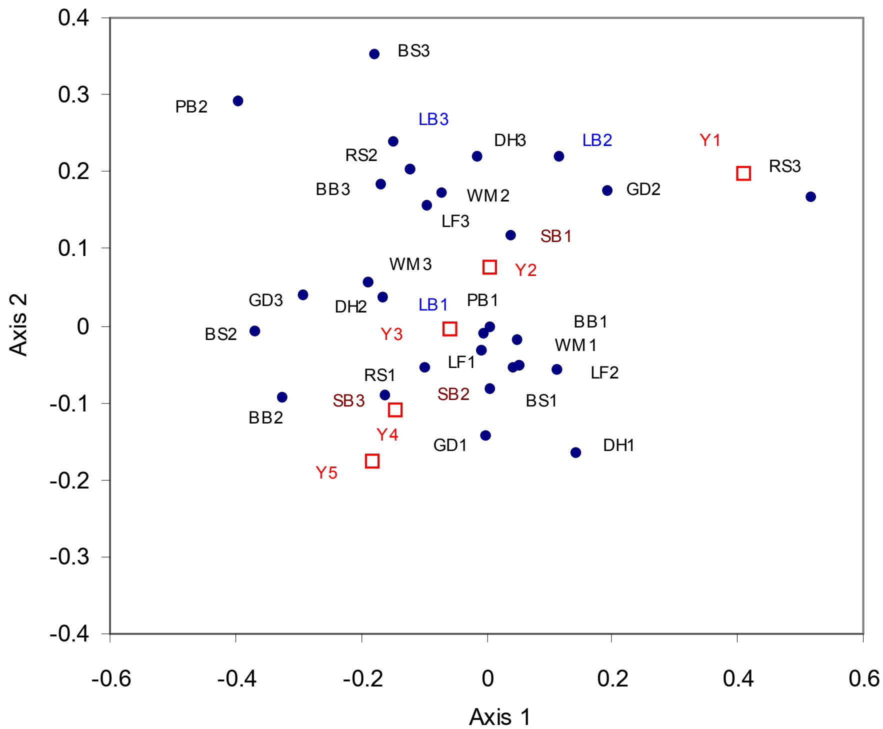


Figure 3: Correspondence analysis between grain yield and pest injuries. Axis 1 and 2 are represented horizontally and vertically, respectively, respectively. The axes are defined using classes of categorization. The successive classes are indicated relationship between levels of yield in field plots and different of pest injuries in six sites of tropical Asia.

Principal component analyses were performed to obtain a better understanding of the most important components among variables (except yield). The analysis resulted in sixteen factors explained for 100 % of variance, among factors generated there are 4 factors (PC1, PC2, PC3, and PC4) contributed for 95.56 % of variance.

Results from stepwise multiple regression using actual yield [$Y_{(ac)}$] as dependent variables showed that actual yield needs to be explained by injuries as independent variables. The equation resulting from the stepwise multiple regression was:

$Y_{(ac)}$= 5692.04 - 55.13 (RS) + 77.53 (SHB) + 76.52 (GD) - 160.71 (AW)

- 238.91 (DH) - 305.44 (RB)

$F_{(N)}$ = 126.54 - 3.65 (GD) - 7.37 (RB) + 2.31 (SB) + 1.06 (LF) - 2.05 (AW)

DISCUSSION

Many diseases and insects were recorded, but some damage was of very low incidence. Diseases like false smut, kernel smut, leaf scale, bacterial leaf streak, rice tungro virus, ragged stunt virus and red stripe appeared only in some sites. At the time of the survey, destructive and widespread diseases such as LB and PB caused by *Pyricularia grisea* Cav. (Rossman et al. 1990) were recorded with low incidence, as happened with a previous survey (Savary et al. 2000). The disease is controlled by using host resistance, but a change to a more virulent pathogen can be very much affected by environment, especially in tropical and humid conditions.

Insects like thrip, rice hispa, gall midge, brown plant hopper and hopper burn were recorded as site specific and very low incidence. GM (*Orseolia oryzae*) usually occurs with high incidence when continuous rain in wet season. RB (*Leptocorisa oratorius*) was observed during milky stage in all sites. A high population of RB will cause unfilled-grains. Rat damage was observed in site of Indonesia and Vietnam and weed infestation were observed only in Vietnam site. Some diseases and pests are site-specific and affected by weather conditions. Reduction of N application in SSNM could lead to less incidence of some damage by SHB, LF and DH for example but BS, RS, BB, GD were severe in all seasons.

Cluster analysis clearly indicated that for intensive irrigated rice systems class IN1 is most dominant with a high incidence of BB, BS, NBS, RS, SHB, GD, WM, LF and DH at most sites. It prevailed in China, Vietnam, Philippines and India but not Indonesia. IN2 prevailed only in North Vietnam where BB and SB were of high incidence and the mean actual yield is highest at 5.8 t ha^{-1} with the least N applied. Transplanting there is common practice and farmers ware most interested with hybrid rice, which yielded higher than improved rice by 1-2 t ha^{-1}.

Results of the stepwise regression analysis provided more information for identifying key pest profiles. Regression (Y_{ac}) accounted for 35 % of yield variation, and the other equation (F_N), clearly indicated that SB and LF were positively increased by increased levels of N. Evidence from Figure 3 shows that GD3 and SB3 were among complex interactions of high yield (Y3, Y4) and high N rates applied. Logically, SB incidence was affected directly by N levels (Du, 1995), and GD would be important factor for yield loss of successive rice crop. Information from this analysis shows that pest incidence accounted for yield variation, level of nitrogen applied associated with pest levels. Optimunm rate of N used in SSNM at each site and season with low pest incidence need to be further studied

REFERENCES

Buresh RJ, and C Witt. 2002. Fertilizers and fertilizer management: Balanced nutrient use, overview of site-specific nutrient management (SSNM), and development of nutrient recommendations.

Cassman KG, SK De Datta , ST Amarante, SP Liboon, MI Samson, and M Dizon. 1996. Long term comparison of agrnomic efficiency and residual benefits of organic and inorganic nitrogen sources for tropical lowland rice. Exp. Agric. 32: 427-444.

Du PV. 1995. Sheath blight dynamics as affected by changes in microclimate and Nitrogen application in different plant types, Ph.D thesis, University of the Philippines at Los Banos, College, Laguna.

Du PV and S Savary. 1997. A survey of rice constraints in the Mekong delta. Intern. Rice Res. Notes 22: 43-44.

Greenace MJ. 1984. Theory and Application of Correspondence Analysis. Academic Press, London.

Heong KL, MM Escala, AA Lazaro. 1995a. Missue of pesticides among rice farmers in Leyte, Phhilippines. In Impact of Pesticides on Farmers' Health and the Rice Environment, P.L. Pingali and P.A. Roger (eds). Kluwer Academic, Norwell, MA, pp 97-108.

Heong KL, NT Thu Cuc, N Binh, S Fujisaka, DG Botrell. 1995b. Reduction early season insecticide applications through farmers' experiments in Vietnam. In Vietnam and IRRI: A partnership in Rice Research, G.L. Denning and V.T. Xuan (eds). International Rice Research Institute, Los Banos, Philippines and Ministry of Agriculture and Food Industry, Hanoi, Vietnam, pp 217-222.

Huber DM. 1980. The role of mineral nutrient in defense. In J.G. Harfall and E.B. Cowling (eds) Plant Disease, Vol. V, 381-406. Academic press, New York.

Hardter R. 1996. Crop nutrition and plant heath of rice -based cropping systems in Asia. In: Maximizing Sustainable Rice Yields Through Improved Soil and Environmental Management, pp 179-195. Proceedings, Symposium of the Paddy Soil Fertility Working Group, ISSS, Khon Kaen, Thailand, 11-17 November 1996.

International Rice Research Institute. 1990. Crop Loss Assessment in Rice.

International Rice Research Institute, Los Banos.

Marschner H. 1995. Relationship between mineral nutrition and plant diseases and pests. In: Mineral Nutrition of Higher Plants. 2nd ed., Academic Press, London, pp. 436-460.

Mew TW, NP Castilla, FA Elazegui, CM Vera Cruz. 2001. The etiology of red stripe of rice: current status and future directions. Itern. Rice Res. Notes 26-1: 4-10

Mikkelsen DS. 1987. Nitrogen budgets in flooded soil used for rice production. Plant Soil 100:71-79.

Peng S, FV Garcia, RC Laza, AL Sanico, RM Visperas, KG Cassman. 1996. Increase N-use efficiency using a chlorophyll meter on high-yielding irrigated rice. Field Crops Res. 47: 243-252.

Rossman AY, RJ Howard, B Valent. 1990. *Pyricularia grisea*, the coorect name for the rice blast disease fungus. Mycologia, 82, 509-512

Savary S, L Willocquet, FA Elazegui, N Castilla, and PS Teng. 2000. Rice Pest Constraints in Tropical Asia: Quantification of yield losses due to rice pests in a range of production situations. Plant Disease, Vol 84-3, pp 357-369.

Savary S, L Willocquet, FA Elazegui, PS Teng, PV Du, D Zhu, Q Tang, S Huang, X Lin, HM Singh, RK Srivastava. 2000. Rice Pest Constraints in Tropical Asia: Characterization of Injury profiles in Relation to Production Situations. Plant Disease, Vol 84-3, pp 341-356.

Savary S, RK Srivastava, HM Singh, FA Elazegui. 1997a. A characterization of rice pests and quantification of yield losses in rice wheat system of India. Crop Protection Vol 16-4, pp 387-398.

Savary S, FA Elazegui, Pinnschmidt and PS Teng. 1997b. Characterization of rice pest constraints in Asia: an empirical approach: Applications of System Approaches at the Farm and regional Levels, 83-98, P.S. Teng (eds.), Kluwer Academic Publishers. Printed in Great Britain.

Savary S, LV Madden, JC Zadoks and HW Klein-Gebbinck. 1995. Use Categorical Information and Correspondence Analysis in Plant Disease Epidemiology. Advances in Botanical Research Vol 21, 214-233

Savary S, FA Elazegui, and P Teng. 1996. A survey porfolio for the characterisation of rice pest constraints. IRRI Discussion Pap. Ser. 18, LosBanos, Philippines.

Sherpard BM, HD Justo, EG Rubia, DB Estano. 1990. Response of the rice plant to damage by the rice whorl maggot, *Hydrella philippina* Ferino (Diptera: Ephydridae). J. Plant Protect. Tropics 7, 173-177.

Teng PS, KL Heong (Eds.). 1988. Pesticide management and Integrated Pest Management in Southeast Asia. Consortium for International Crop Protection, College Park, U.S.A.