International Pesticide Benefit Case Study 108
October, 2014

Importance of Pesticides for Growing Rice in South and South East Asia

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INTRODUCTION

Rice is an essential crop for feeding the populations of South and South East Asia. Rice provides more than 50% of the calories consumed in Bangladesh, Cambodia, Myanmar, Laos, and Vietnam and 20-44% in Thailand, Philippines, Malaysia, India, Nepal and Sri Lanka. Wide yield gaps are still present in farmers' fields in Asia and closing these gaps can contribute to further increases in rice supply to meet future demands. In most Asian countries, rice yields average 3-5 t/ha. Experiments with the intensive use of pesticides has determined that the yield potential of rice varieties in Asia is about 10 t/ha.[4] One recent Study estimated that between 120 and 200 million tons of grain are lost yearly to insects, diseases, and weeds in rice fields in tropical Asia.[14] The mean region-wide rice yield loss due to pests was estimated at 37%.[15]

There is huge scope for significant increases in rice productivity in Asia through adoption of Good Agricultural Practices particularly judicious use of pesticides. A study of yield-limiting factors in tropical Asian rice fields determined that fungicide, insecticide and herbicide use were all positively associated with higher yields.[5]

Rice Field With Sheath Blight

FUNGICIDES

Collectively, rice diseases result in yield reductions of 10-15% in tropical Asia.[15] Sheath blight and blast are present wherever rice is grown; these two diseases are responsible for losses of 5% or more each.

The blast fungus overwinters in rice straw and stubble and spreads rapidly by airborne spores. The pathogen can infect any organ of the rice plant. When it hits the head or neck, blast stops nutrients and water from getting to the kernels. Portions of the grain head will be white in contrast to the green or tan color of healthy grain. This "blasted" appearance is caused by blank grain. Severe infestations lead to large areas of dead plants. In the first recorded outbreak of blast in India in 1918, the loss in rice production was estimated at 69%. Blast epidemics in Malaysia and the Philippines have caused yield reductions of 50-70%.[2] Rice varieties resistant to blast frequently lose their resistance within a few years because of shifts in strains of the fungal population.[1]

Sheath blight is caused by a fungus that lives in the soil; the fungus floats to the top when fields are flooded, contacts rice plants and spreads to adjacent plants. Spread of sheath blight is thus favored by dense crop canopies. The flow of water and nutrients in the rice plant is interrupted and the leaf dies, reducing rice yield. Sheath blight has developed into a major disease only since the intensification of the rice-cropping system with new short-statured, profusely-tillering varieties, high planting densities and an increase in nitrogen fertilization inducing a favorable microclimate for the pathogen. In Malaysia, 15-20% of the total rice area is estimated to be infected with the disease and in 1993, losses of 17-25% occurred.[8] A dramatic increase in sheath blight occurred in Vietnam with 200,000 hectares infected in 1990-91. Losses due to sheath blight are at least 10% in India and in Thailand it can account for more than 20% annual loss.[9] In Bangladesh, contribution of rice yield loss due to sheath blight out of total loss in farmers' fields is about 30%.[10] It has been difficult to breed varieties with a high genetic resistance to sheath blight, so the disease has to be managed through use of chemical fungicides.[9, 10]

Several fungicides have long been recommended for blast and sheath blight control in Asia. A two-spray program has proven highly effective resulting in 84-88% reduction in blast and 30-34% increase in rice yield.[6] The cost:benefit ratio for fungicide use to control blast has been estimated at 1:7 to 1:12.[7] In tests in India, new fungicides for sheath blight control have resulted in rice yield increase of 20%.[11]

Fungicide use in rice in South Asia is highest in India and Vietnam where more than75% of the farmers apply.[12] Following epidemics of rice blast in India, the milling industry distributed sprayers and fungicides to farmers. In other South Asian countries, fungicide use on rice is negligible.[12] Farmers and agronomists across the region have not been adequately trained to correctly diagnose the diseases. In Vietnam as a result of trainings in disease diagnosis and fungicide applications, use of fungicides by farmers practicing IPM has more than doubled.[13] Fungicide use is expected to increase in rice in Asia as higher rice yields are sought.

HERBICIDES

Weeds flourish in the humid climates of rice fields in South and South East Asia. Without any control, weeds can completely overwhelm the rice crop. The traditional method for weed control in Asian rice fields is hand weeding. Weeding rice adequately requires 30-120 man-days/hectare. Typically, two to three hand weedings are recommended for optimal weed control. However, especially at the time of peak period of labor demand, weeding is either done late, or skipped, causing drastic losses in rice yield.[16] Some farmers abandon weeding due to heavy infestations, particularly after rains. Farm families typically are unable to do weeding all on their own and need to hire labor.[17] Labor availability on time and the costs are becoming extremely problematic.[17]

A survey of rice fields in tropical Asia determined that weeds were the most significant pest factor in reducing yields: rice yields were being reduced by 23% from weeds growing above the rice canopy and by 21% from weeds growing below the rice canopy (figures are not additive, but considered individually).[15] In India, annual loss in rice due to weeds has been estimated at 15 million tons.[20] On average, the gap in rice yields in farmers' fields due to poor weed control in Bangladesh was determined to be 43-51%.[16] The yield gap was as high as 1 t/ha with 30% of farmers losing in excess of 500 kg/ha.[17]

Herbicide Treated (Bottom) Not Treated (Top)

As Asian economies have been industrializing, millions of people are migrating from rural to urban areas, creating shortage of workers for hand weeding and increasing the cost of hand weeding even when labor is available. Wages for farm workers in South East Asia have increased; the average wage rate in the 2010s is five times greater than in the 1970s. Increases of 100 to 200% in the current labor price are realistic expectations within the next 5-10 years.[18] Farmers are left with little choice but to reduce labor costs, particularly for the most labor-intensive tasks, such as weeding.[19]

Research in India has shown that in rice farms using herbicides, per hectare labor usage was about 43 hours lower, yields were higher by about nine quintals (0.9t) and profits were increased by Rs.3673.[21] Research in Bangladesh demonstrated that herbicide applications would produce similar rice yields to three carefully timed hand weedings with a significant reduction in labor requirements and total costs ($9/ha vs $186/ha).[17] Economic analysis of rice production in Bangladesh revealed that the net income from herbicide application was 116% higher than hand weeding three times.[16]

INSECTICIDES

In South and South East Asia rice is grown in warm, humid environments conducive to the survival and proliferation of key insect pests: the yellow stemborer, leaffolders, brown plant hoppers (BPH) and green leafhoppers. Stemborers are ubiquitous throughout rice fields in Asia and cause some damage in every rice field every year. The larvae bore into the stems and eat their way down to the base of the plant hollowing out the stem. Losses from borer damage can reach up to 95%. Leaffolder larvae fold the leaves by stitching the leaf margins and feed by scraping green leaf tissue. Yield losses because of leaffolders range from 63 to 80%. BPH sucks sap from the rice plant causing the plant to dry out, turn brown and die. This condition is called hopperburn and it can cover large patches in rice fields. The brown plant hopper also transmits the ragged stunt and grassy stunt viruses. The green leafhopper is a vector of Tungro virus.

Historically, stem borers were the most important insect pest of rice causing yield losses of 70% in epidemic years.[25] The introduction of high yield technology in the 1960s involving rice varieties with high tillering ability, denser plant spacing, high fertilizer application and irrigation where farmers planted 2 or 3 rice crops a year provided abundant habitat for leaf hoppers and leaffolders that enabled the populations to reproduce nearly year round. Further, the use of nitrogen fertilizers increased the insects' reproductive potential.[22] The desire to realize the full potential of the new high-yielding varieties led to intensive testing of broad spectrum insecticides. In 117 experiments conducted by IRRI over 15 years, insecticide treated plots yielded 87% higher than the untreated.[23] The benefit/cost ratio varied from 3 to as high as 10.[26] The use of insecticides expanded rapidly in Asia in the 1970s and 1980s. Most Asian governments provided subsidies for insecticide purchase and farmers were required to purchase insecticides along with fertilizers in their loan packages.

Rice breeding programs have given priority to the BPH problem. However, rice varieties have succumbed because of the development of BPH biotypes which can destroy the resistant varieties. The first high-yielding rice cultivar with BPH resistance was released in 1973 and was successful for two years. The resistance of varieties introduced in the 1970s and 1980s lasted until 1991. Resistant varieties have not been developed for yellow stemborers.[24]

Since the 1970s, hundreds of millions of dollars have been spent by international organizations and Asian governments to develop and promote Integrated Pest Management (IPM) techniques for rice insects. An important component has been the training of extension personnel and farmers to diagnose and monitor pest problems in the field and to use insecticides judiciously only when needed. In order to

Brown Plant hoppers

promote the adoption of IPM, Indonesian officials banned 57 broad spectrum insecticides in 1985. The ban left farmers with no foliar insecticides to control stemborers. As a result, over 300,000 people had to be mobilized to destroy egg masses by hand during a late 1990 migration of stem borer moths.[27]

Insecticides are used to varying degrees in Asian rice fields (% hectares treated to total rice cultivated area): Cambodia (38%), Indonesia (75%), Malaysia (70%), Philippines (95%), Thailand (58%), Vietnam (99%), Bangladesh (50%), and India (50%).[12] On average, Asian rice farmers apply insecticides 2-4 times per growing season.[28,29,30] Rice losses to insect pests are low in tropical Asia. Among the insects, only damage by stem borers appear to be of relevance (2.3%).[15] Introduction of new selective insecticides non-toxic to natural enemies has improved the management of rice insect pests.[31] Insecticide testing for stemborer control continues to show large increases in rice yield (+70%).[3] Insecticide sales in rice in South and South East Asia increased from US$409 million in 2009 to US$674 million in 2012 as a result of increased adoption of new selective insecticides and their increased use particularly in India.[32]

CONCLUSIONS

South East Asian rice production increased about 40% from 2000 to 2013 while rice production in South Asia increased about 30%. Increased use of pesticides has been one of the significant contributing factors to these increases. Further adoption of fungicides and herbicides will help increase production in the years to come while adoption of new selective insecticide products will continue to improve insect management.

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