PLANT DISEASES

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Abstract: It is a little over three decades since the first improved rice variety was released by the Department of Agriculture (DOA) in an attempt to increase rice production through the improvement of the genetic background of varieties. This programme, which included incorporation of disease resistance, resulted in the development of the first new variety, H 4. It was resistant to blast, which was the most widespread disease that caused considerable yield loss in varieties grown at that time. Since the release of H 4, about 25 new improved varieties were released by the DOA. They had the desired plant traits and also the resistance to blast and other diseases which were becoming important with the passage of time. Plant diseases that existed marginally soon became prominent, and frequent occurrences were reported. The bacterial blight disease became important as a field problem in the 1960s and sheath blight started to cause damage in the 1970s. Leaf yellowing was reported to be a field problem commencing 1980, but its etiology, ecology and epidemiology are still not known well. This paper presents an overview of the current status of plant pathological problems associated with rice cultivation in Sri Lanka. Recent research findings in this area are discussed and strategies to overcome or minimize these problems are suggested. Future strategies for the control of most plant diseases lie in an integrated effort of the plant breeder, plant pathologist and agronomist. The major task of the pathologist will be to investigate the nature of host resistance and the plant pathogen. This will enable to find suitable donor varieties. The agronomist should develop an appropriate package of cultural and management practices to prolong the durability of resistant varieties while keeping the disease occurrence to a minimum. The use of fungicides should be the last resort for disease control.

INTRODUCTION

It is a little over three decades since the release of the first improved rice variety, H 4 by the Department of Agriculture (DOA) in an attempt to increase the production through the improvement of the genetic background of varieties. Incorporation of disease resistance into the new varieties continues to be an important objective of the rice breeding programme since its inception in early 1950s. Pachchaiperumal 2462/11, a 3-month variety grown in the dry zone in yala and Podiwee A 8, a popular variety grown in the wet zone, at that time, were very susceptible to the disease. H 4 exhibited a very high level of resistance to rice blast, the predominant field disease that caused considerable yield losses.

At the beginning, the main breeding objective was to develop high yielding varieties. The varieties developed were highly responsive to fertilizer use and were resistant to blast. But diseases that existed marginally, subsequently became prominent and their occurrences were frequently reported. For example, the bacterial blight disease gained prominence as a field problem in the late 1960s (Seneviratne, 1980) and sheath blight was reported to cause considerable losses in early 1970s. The leaf yellowing disorder has been a field problem from the beginning of 1980, but its etiology, ecology and epidemiology are not understood still. During 1984-85, virus diseases, such as ragged stunt, tungro and grassy stunt were reported as field problems (Peries *et al.*, 1985). This may have been due to a change in the rice pest status in Sri Lanka as the planthopper and leafhopper, vectors for these diseases, were found to be frequent during this period.

This paper presents an overview of the current status of plant pathological problems associated with rice cultivation in Sri Lanka. Recent research findings in this area are discussed, and strategies to overcome or minimize damage due to diseases are suggested.

PRESENT STATUS

Among the more important diseases in Sri Lanka are rice blast (*Pyricularia oryzae* Cav), bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*) and sheath blight (*Rhizoctonia solani* Kuhn) which continue to cause significant damage to rice in localized areas depending on varieties grown, agroclimatic conditions and agronomic practices followed. Sheath rot (*Sarocladium oryzae* Sawada) and grain discolouration have been reported as potential field problems in the southern area. The yellowing disorder of rice has been reported from various parts of the country coming under most agroecological zones. Rice virus diseases were reported as a major field problem during 1983/84 in a large extent of rice-lands in the south and in the Mahaweli area. At present we possess a considerable amount of knowledge on diseases, predisposing factors for epidemics and their economic significance (Wickramasinghe, 1987).

Rice blast

This disease continues to be an important field disease. Blast incidence is seen mainly at two crop growth stages, namely the seedling and flowering stages. Seedling blast is prevalent in the eastern province and Badulla where predominantly upland rice is cultivated. Panicle blast has been reported frequently in both upland and lowland rice cultivation, mainly during the maha season when the flowering period coincides with conditions favourable for the development of the disease. It is interesting to note that although most recommended varieties are susceptible to blast at the seedling stage, only a few succumb to the disease at the flowering stage. It is not clear whether these varieties are resistant to blast at the flowering stage or the environmental conditions are not favourable for the development of the disease. Among the control measures available, the use of fungicides is expensive and cannot be practised in most farmers' fields. Therefore, the use of resistant varieties must be encouraged. This is the best means of control of the disease under the farming situations in Sri Lanka.

In the breeding programme, only seedling blast reaction is made use of in the selection of progenies as there is no reliable screening method to test rice varieties for their response to blast at the flowering stage. Initially, screening for blast was done at Karadian Aru, Karapincha and Peradeniya. Only breeding lines that showed a high level of resistance across the above screening sites were considered for selection and advancement. Karadian Aru was an important location situated in the eastern province where seedling and panicle blast incidences are frequently reported as a major field problem. However, due to socio-political reasons the Karadian Aru blast screening site has not been used for blast screening for over 15 years. At present, screening against the disease is confined to Peradeniya and Batalagoda.

A close look at the blast reaction pattern of recommended rice varieties released over the last 10 years shows that varieties showing resistance to seedling blast at the time of recommending, became highly susceptible few years later (Table 1). This observation suggests a possible shift in the frequency of different races in the blast pathogen population. Varieties that showed a fairly high level of resistance to blast have lost it with the passage of time (Table 1).

According to our observations varieties that show the highest level of resistance (RR) have generally continued to maintain their resistance. Varieties with an intermediate level of resistance tend to move down the scale of resistance, several years after recommendation. This suggests that when new sources of blast resistance are used in the breeding of new varieties they should posses a high degree of resistance in order to prevent the breaking down of resistance.

Locational differences of blast resistance in Sri Lanka

Locational differences of blast resistance among breeding lines and recommended varieties were seen in an experiment conducted during yala 1989 at Batalagoda, Makandura and Gannoruwa. During maha 1989/90 the experiment was repeated at Peradeniya and Batalagoda. The objective of the test was to detect the spectrum of resistance of the different varieties under a broader range of agroecological conditions, and to detect if the race composition was different from one location to another.

The results of the test showed that among the recommended 3-3 1/2 month varieties only Bg 300, Bg 301 and 62-355 showed a broad spectrum of resistance, being resistant in all 3 test locations (Tables 2 and 3). Most of the 4-4 1/2 month varieties were resistant at Batalagoda and Makandura but susceptible at Peradeniya. The overall results indicated that most of the varieties recommended at the Central Rice Breeding Station (CRBS), Batalagoda are either moderately susceptible or susceptible at Peradeniya.

Table 1. Seedling blast reaction of selected rice varieties at CRBS, Batalagoda

Variety	*Season*										
	maha 79/80	*maha 80/81*	*maha 81/82*	*yala 82*	*maha 82/83*	*maha 83/84*	*maha 84/85*	*maha 86/87*	*maha 87/88*	*yala 89*	*maha 89/90*
Bg 3-5	MR/MS	MR/MS	MR	MR/MS	MR	MR/MS	-	-	MR/MS	-	MS
Bg 407	R	R	MR	MR	R	R/MR	-	-	MR/MS	R	R/MR
Bg 745	R/MR	R	R	MR	R	R/MR	-	-	MS	-	MS
Bg 90-2	MR/MS	R/MR	MS	MR	MR/MS	MR	-	-	S	-	S
H 4	MR	R/MR	MR	R	R	R	R	MR	R	R	MR
Bg 400-1	MR	R/MR	R/MR	R/MR	MR/MS	MR	MR	MS	S	MS	S
Bg 379-2	R	MR	R	R/MR	MR	MR	MR	MR	MR	R	R
Bg 380	-	R/MR	R/MR	MR	MR/MS	MR	MR	MR/MS	S	S	S
Bg 11-11	R	MR	R/MR	R/MR	R	-	-	MR	R	R	MR
Bg 12-1	R	R/MR	-	R/MR	R	-	R	MR	R	R	R
Bg 450	-	-	-	-	-	R	R	MS	S	MS	S
Bg 34-6	MR/MS	MR/MS	MS	MS	MR/MS	-	MR/MS	MR	S	S	S
Bg 94-1	MR/MS	MS	MS	MR/MS	S	MS	MS	MS	MR/MS	S	S
Bg 34-8	S	MS	S	MS	MS/S	MS	-	S	S	S	S
Bg 276-5	MR	MR	MR/MS	MR	MS	MS	-	MS	S	S	S
Bg 300	-	-	-	-	-	-	-	R	R	R	R
Bg 301	-	-	-	-	-	MR	MR	MR	R	R/MR	R
62-355	R/MR	MR/MS	MR/MS	MR	MR	MR	-	R	R	R	R/MR
Tetep	R	R	R	R	R	R	R	R	R	R	R
PP	S	S	S	S	S	S	S	S	S	S	S

Source: Upland blast screening data 1977-90, CRBS, Batalagoda, Unpubl.
R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible
Two ratings separated by a stroke (/) indicates that the rating is in between two ratings

Table 2. Seedling blast reaction of selected recommended rice varieties at three different locations in Sri Lanka

Category	*Variety*	*Location*		
		*Batalagoda***	*Makandura***	*Peradeniya****
3 months	Bg 300	R	R	R
	Bg 34-8	S	MS	S
	Bg 276-5	S	MS	S
	Bg 301	R	R	R
3 1/2 months	Bg 34-6	S	MS	S
	Bg 94-1	S	S	MS
	Bg 350	S	S	MS
	H 7	SS	MS	S
	62-355	R	R	R
4 months	Bg 400-1	S	S	S
	H 4	R	R	S*
	Bg 11-11	R	R	S*
	Bg 12-1	R	MR	S*
	Bg 379-2	R	R	S*
	Bg 450	MS	MS	S
	Bg 380	SS	S	MS/S
5-6 months	Bg 407	R	R	MS/S
	Bg 38	R/MR	R	MS*
	Bg 745	MR	R	MS*

Source: Yala 1989 Report, CRBS, Batalagoda, Unpubl.

R = Resistant; MR = Moderately resistant; MS = Moderately susceptible;
S = Susceptible; SS = Highly susceptible

Two ratings separated by a stroke (/) indicate that the rating is in between the two ratings
- * Indicates a distinct differential reactions at two or all locations
- ** Screening done only in yala 89.
- *** Average reaction of yala 89 and maha 89/90

Table 3. Seedling blast reaction of selected elite varieties at three different locations in Sri Lanka

Variety	*Location*		
	*Batalagoda****	*Makandura***	*Peradeniya****
Bg 1165-1	MS	MS	MS
Bg 915	R	MS	MR/MS*
Bg 850-1	R	R	R
Bg 1564	SS	R/MR	S*
Bg 1575	SS	R/MR	MS*
Bg 1203	R/MR	R	R
Bg 1219	R	R	R
Bg 936	R	R	R
Bg 1112	R	R	R/MR
Bg 846	R	R	MS*
Bw 298-2	SS	S	S
Bw 297-2	R	R	MS*
At 85-1	R	R	R
At 86-1	R	R/MR	SS*
At 76-4	SS	S	SS
At 84-2	SS	S	SS
Ld 179-1	R	R	MS/S*
Ld 179-4	R	R	MS/S*
PP	SS	SS	SS
Tetep	R	R	R

Source: Yala 1989 Report CRBS, Batalagoda, Unpubl.

R = Resistant; MR = Moderately resistant; MS = Moderately susceptible;
S = Susceptible; SS = Highly susceptible

Two ratings separated by a stroke (/) indicate that the rating is in between the two ratings

* Indicates a distinct differential reactions at two or all locations
** Screening done only in yala 89
*** Average reaction of yala 89 and maha 89/90

These observations confirmed that there is a locational difference in blast resistance among rice varieties between the Batalagoda and Peradeniya test sites (Tables 2 and 3). This indicated the possible existence of different blast races at these 2 locations. The race predominant at Peradeniya seems to be more virulent than those present at Batalagoda and Makandura, because most varieties/lines resistant at Batalagoda or at Makandura showed a moderately susceptible or susceptible reaction at Peradeniya. The races present at Batalagoda and Makandura appear to be similar in nature as the varietal reaction for blast follows the same trend. This finding suggests the importance of repeated testing over a period of time in different locations and under varying climatic conditions before making a final conclusion on the performance of a variety to be recommended.

Identification of predominant field races of P. oryzae in different blast screening sites

Detection of locational differences in blast resistance among rice varieties at the blast screening sites at Batalagoda and Peradeniya suggested the possible presence of different races at the 2 sites. Experiments conducted using international rice blast differential varieties, along with some other rice varieties helped to identify the major races of *P. oryzae* at Batalagoda and Peradeniya. The test showed that the international race group, IF is the predominant field race at Batalagoda while the international race group, IC was found to infest the Peradeniya test site (Table 4).

These research findings are useful when selecting blast resistant donor parents from other countries using International Rice Testing Programme (IRTP) nurseries. Entries selected for the local breeding programme should necessarily be resistant in countries where race groups IF and IC are found to be dominant. However, since only two locations were included in the study, one could suspect other race groups to predominate in other parts of th country, specially in areas where seedling blast and panicle blast are frequent field problems. In addition, the presence of different race groups at different locations justify the need for multi-locational screening against the disease.

Genetic base of resistance for seedling blast among recommended rice varieties in Sri Lanka

Analysis of the genetic ancestry of varieties recommended in Sri Lanka has clearly shown that the overall gene base is very narrow (Jayawardena *et al.*, 1987). An experiment was conducted to determine the genetic base of blast resistance among rice varieties in Sri Lanka. Twenty-four recommended varieties and their nucleus parents were screened for seedling blast resistance using the upland seed bed technique at Peradeniya and Batalagoda, during maha 1989/90. Two screenings were done per location within the season. Pachchaiperumal 2462/11 was used as

Table 4. Reaction of the international rice blast differential (IRBD) varieties and some commercial rice varieties at two blast screening sites - maha 1989/90

Category	*Variety*	*Blast reaction*	
		Batalagoda	*Peradeniya*
IRBD varieties			
	Raminal str.3	R	R
	Zenith	R	R
	NP 125	R	S*
	Usen	R	R
	Dular	R	S*
	Kanto 51	S	S
	Sha-tiao-tsao	S	S
	Caloro	S	S
Commercial varieties			
3 months	Bg 34-8	S	S
	Bg 275	S	S
	Bg 300	R	R
	Bg 301	R	R
3 1/2 months	Bg 34-6	S	S
	Bg 94-1	S	S
	62-355	R	R
4 months	Bg 400-1	S	S
	Bg 450	S	S
	Bg 11-11	R	S*
	Bg 12-1	R	S*
	Bg 379-2	R	S*
	H 4	R	S*
5-6 months	Bg 3-5	MR	MR
	Bg 407	R	S*
	Bg 38	R	S*
	Bg 745	MR	MS

Source: Maha 1989/90 Report, CRBS, Batalagoda, Unpubl.

R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible

Two ratings separated by a stroke (/) indicate that the rating is in between the two ratings

* Indicates a distinct differential reactions at two locations

the susceptible standard variety and Tetep was used as the standard resistant variety. The nursery plot design, fertilization, seed bed methods and evaluations were made according to the International Rice Research Institute (IRRI), Standard Evaluation System. Results are given in Tables 5 (Peradeniya) and 6 (Batalagoda). The results show that at Peradeniya the resistance in recommended varieties may have been derived as follows (Table 5) : When both blast screening sites are taken together, only varieties Ptb 33, Tetep, Engatek and BP1 76 provide resistance in common at both locations for some recommended rice varieties in Sri Lanka. On the other hand, only the variety Tetep is considered a good blast resistant source while the other two are used to incorporate other characters like brown planthopper resistance. This indicates that the gene base for blast resistance of recommended rice varieties in Sri Lanka is very narrow.

This situation is very alarming as several plant disease epidemics such as the potato leaf blight epidemic in Ireland and southern corn blight in USA were due to the use of crop varieties with a very narrow genetic background.

Bacterial blight

Bacterial blight is the most important bacterial disease in Sri Lanka. This gained prominence for the first time in late 1960s in the Kurunegala district with the introduction of semi-dwarf high yielding varieties. This disease has been found in various rice growing regions in the country. Fortunately, economic losses have been observed only in localized areas like Kegalle, Kurunegala and Kandy. The disease incidence depends on the cultivar, soil fertility, weather conditions and season. The disease normally assumes epiphytotic proportions during both maha and yala. *X. campestris* pv. *oryzae* is known to cause seedling blight or 'Kresek' during early growth stage and 'Leaf blight' at active tillering and booting stages.

Variation and specialization in bacterial blight

In Sri Lanka, following the first outbreak of the disease, some attempts have been made to study factors that contribute to the occurrence and spread of the disease. No pathogenic specialization was seen as determined by the varietal reaction to a large number of isolates collected from 5 districts in wet zone namely, Kandy, Matale, Kurunegala, Kegalle and Nuwara Eliya (D.M.N. Dissanayake, 1983, Unpubl.).

It was observed that elite breeding lines developed at the Regional Agricultural Research Centre (RARC), Bombuwela and Agricultural Research Station, Ambalantota, succumb to the disease naturally at Batalagoda. This suggests two major possibilities. One is that bacterial blight may be a very rare field disease in Bombuwela and Ambalantota areas, as otherwise the elite

Table 5. Possible source of blast resistance in some recommended rice varieties as observed from blast reaction at Peradeniya

Recommended variety	*Blast reaction*	*Parent variety that may have contributed resistance in recommended variety*	*Blast reaction of parent variety*
Bg 300	R	Ptb 33	R
		Tetep	R
Bg 301	R	Kn 361-1-8-6	MR
Bg 379-2	MR	Ptb 33	R
Bg 3-5	MR	Mass	MR
		Engatek	R
Bg 745	MR	-	-
Bw 272-6B	MR	BP1 76	R

Table 6. Possible source of blast resistance in some recommended rice varieties as observed from blast reaction at Batalagoda

Recommended variety	*Blast reaction*	*Parent variety that may have contributed resistance in recommended variety*	*Blast reaction of parent variety*
H 4	R	M 302	R
Bg 379-2	R	Ptb 33	R
Bg 11-11	R	Engatek	MR
		H 8	MR
Bg 300	R	Ptb 33	R
		Tetep	R
Bg 301	R	M 302	R
Bg 407	R	Panduru Wee	R
Bg 266-603	R	BP1 76	R
		Engatek	R
		H 501	MR
Bw 451	R	Engatek	R
Bg 3-5	MR	Engatek	MR
Bg 38	MR	M 302	R
Bg 745	MR	-	-

lines would have been eliminated in the breeding and selection process, had they been subjected to the disease. This assumption is supported by the fact that Bg 380, a high yielding variety, was not recommended at first as it was susceptible to bacterial blight. However, Bg 380 became a very popular and widespread variety in the Hambantota district as a result of which the DOA was compelled to recommend it as a regional release for the district. The other possibility is that there exists pathogenic specialization where the pathotype found in the Ambalantota area is different from the pathotype present in Batalagoda. An experiment is underway at Batalagoda to detect any pathogenic specialization within *X. campestris pv. oryzae* for isolates collected from dry zone districts.

An experiment was conducted to compare the pathotype group present in Sri Lanka with that identified in Japan and the Philippines. In this study, an isolate of bacterium collected from Batalagoda was used to inoculate a set of differential varieties. It revealed that the pathotype group present in our country is different from those found in Japan and the Philippines (Table 7). The results also showed that the pathotype groups found in Sri Lanka are more virulent than the pathotypes found in Japan and the Philippines. Only the varieties carrying genes Xa 4 and Xa 7 confer resistance in Sri Lanka, while most of the other genes identified confer resistance to Japanese and Philippine pathotype groups. In addition, it shows that the Indian pathotype group IB shows a close relationship to the Sri Lankan pathotype group where they differ in reaction only for variety BJ-1.

Nature of resistance

The most effective and careful selection for a certain character can be achieved only when breeders know the mode of inheritance of a character (whether genic or polygenic), and the characteristics of gene expression. There are two types of bacterial blight resistance in rice. These are qualitative and quantitative resistance, and are categorized from the view point of assessing disease development.

Qualitative resistance is race-specific and shows a high level of resistance. Moreover, qualitative resistance is governed by major genes. As the resistance is race-specific it may breakdown due to the evolution of new races of the pathogen (Ezuka and Sakaguhi, 1978). Already about 14 major genes that confer varying levels of resistance to various races found in the Philippines and Japan have been identified (Ogawa and Khush, 1988). Of these only Xa 4 and Xa 7 confer resistance to the Sri Lankan races.

Quantitative resistance, on the other hand, is race non-specific and considered to be governed by minor genes or polygenes because it does not show a clear-cut mendelian segregation ratio in the hybrid population. It is believed that quantitative resistance is not broken down by the shift of races of the pathogen. However, there is no clear evidence that major gene resistance to bacterial blight in rice is not useful

Table 7. Bacterial blight reaction of international set of pathotype differential varieties and some selected varieties to various pathotype groups identified in different countries

Differential variety	*Resistant gene identified*	*Japanese pathotype groups in Japan*					*Philippine pathotype groups in Philippines*				*Indian pathotype groups in India*			*Sri Lankan pathotype*
		I	II	III	IV	V	I	II	III	IV	Ia	Ib	II	
Kinmaze	None	S	S	S	S	S	S	S	S	S				S
Kogyoku	Xa-1 Xa-12	R	S	S	S	R	S	S	S	S				S
Tetep	Xa-1 Xa-2	R	R	S	S	R	S	S	S	S				S
Chu-goku 45	Xa-3	R	R	R	S	S	R	R	R	R				S
Campo-selek	Xa-3	-	-	-	-	-	-	-	-	-	S	S	R	S
Wasaikoku	Xa-3	-	-	-	-	-	-	-	-	-				S
Java 14	Xa-1 Xa-3 Xa-12	R	R	R	S	R	R	R	R	R	S	S	R	S
IR 20	Xa-1 Xa-4 Xa-12	R	S	S	S	R	R	S	S	S	R	R	S	MR
IR 22	Xa-4	-	-	-	-	-	-	-	-	-				MR
IR 1545-339	Xa-5	R	R	R	R	R	R	R	R	S				S
DV 85	Xa-5 Xa-7	R	R	R	R	R	R	R	R	R	R	R	S	R
Malagkit sung song	Xa-6	-	-	-	-	-	-	-	-	-				S
Khao Loy-Nhay	Xa-9	-	-	-	-	-	-	-	-	-				S
Cas 209	Xa-10	S	S	S	S	S	S	R	S	S				S
IR 8	Xa-11	S	R	R	S	R	S	S	S	S	S	S	S	S
BJ-1	Xa-13	-	-	-	-	-	-	-	-	-	R	R	S	S
TN-1	Xa-14	-	-	-	-	-	-	-	-	-	S	S	S	S

I, II, III, IV, V, Ia and Ib refer to pathotypes to control the disease. Similarly, there is no proof that minor gene resistance is always effective in protecting the rice crop from bacterial blight. Therefore, we need to understand more about the comparative effectiveness of the two types of resistance in controlling bacterial blight as well as the genetics of quantitative resistance.

Breeding for bacterial blight resistance

Incorporation of resistance to bacterial blight was a major objective of the rice improvement programme in Sri Lanka for nearly two decades. Regrettably, we find that no systematic approach has been adopted in this regard. In other words, the first attempt to breed for bacterial blight resistance should have been selection of donor parents to suit the Sri Lankan pathotypes and environment. The reaction of the presently cultivated varieties against bacterial blight and their genetic ancestry do not show that any effective gene was included in them (Table 7). The only known source of resistance is IR 20 with Xa 4 gene which has derived its resistance from Tkm 6. However, screening work and selection for resistance are being practised in the breeding programme, especially at Batalagoda where there is usually a very high incidence of bacterial blight in the field, in both seasons. Therefore, the breeding materials are naturally subjected to sufficient disease pressure. This ensures the selection of only resistant lines. This may be the reason why the presently cultivated varieties except for Bg 34-6 rarely show severe disease symptoms under field conditions. These observations suggest that our rice varieties have a good level of horizontal resistance.

Sheath blight

Sheath blight disease of rice is more common in the wetter parts of Sri Lanka. It could be considered as the most important disease in the low country wet zone. It is also a problem in the Ampara district where farmers resort to the use of high seed rates as a means of suppressing weeds. High plant densities create a favourable micro-climate for fungal growth, and as a result sheath blight is rampant in this area. RARC, Makandura is also confronted with this problem in the area under its purview.

The disease is caused by *Rhizoctonia solani* Kuhn, and is characterized by greyish-green lesions starting on the sheath of the plant at the water level. These lesions enlarge and coalesce on the culm and extend upwards. The leaf blades are often affected when they droop and come in contact with the infected sheaths. In severe cases the symptoms reach the flag leaf which may even become completely desiccated, thereby affect yield considerably (Mithrasena *et al.*, 1987).

Seneviratne (1972) reporting his field investigations concluded that sheath blight does not cause a yield reduction. This view was accepted by the

DOA until work at RARC, Bombuwela by Mithrasena et al. (1987) showed it to be otherwise. According to work cited by Ou (1985), yield loss is dependant on the percentage of hills infected and the extent of spread. When the infection reaches the flag leaf, the yield loss could be as high as 25%.

Experiments on the use different seed rates indicated a positive and significant correlation between seed rate and disease incidence (Fig. 1). In nitrogen and potassium trials, the highest level of nitrogen in combination with the lowest potassium gave the highest disease incidence, producing the lowest grain yield (Table 8). Pencycuron 25% (Monceren) and Triphenyl tin hydroxide (Duter) were found to be the most effective fungicides against the disease when sprayed 24 hours after inoculation. Since this is not practical, spraying at the first signs of the disease is recommended.

Occurrences of the sheath blight disease in farmers' fields in Gampaha, Colombo, Kalutara, Galle, Matara and Ratnapura districts have shown an upward trend as reported by the respective Assistant Directors of Agriculture of these areas.

The use of resistant varieties for sheath blight control is not possible, and hence other measures have to be adopted. Cultural practices like the use of proper seed rate, correct fertilizer rates and use of intermediate tall varieties will be the best means of minimizing the disease incidence. Past experience has shown that the use of a fertilizer mixture containing both N and K, instead of urea alone for top dressings would reduce the disease incidence.

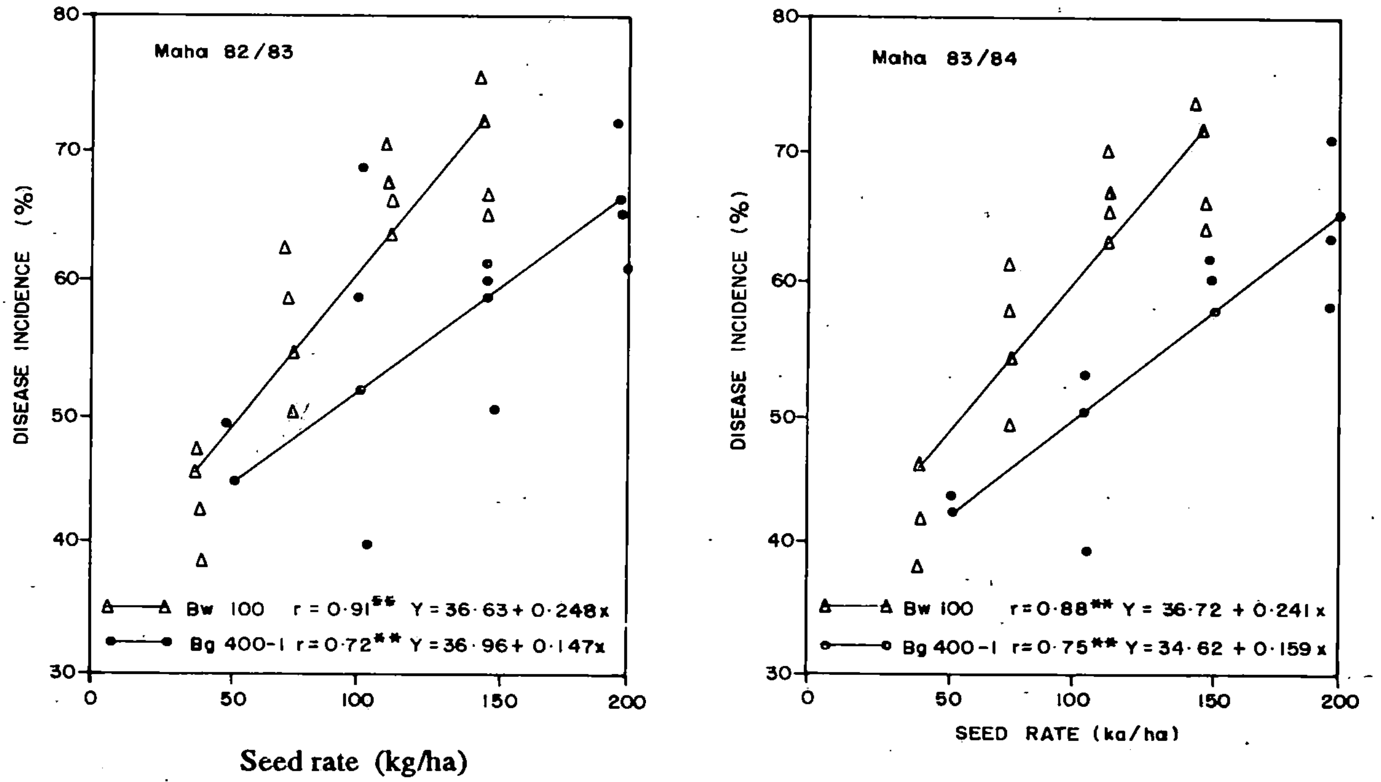

Fig. 1. Disease incidence at different seed rates - maha 82/83 and maha 83/84

Table 8. Effect of different combinations of nitrogen and potassium on sheath blight disease incidence and grain yield of rice

Fertillizer combination	*Disease incidence score*		*Grain yield (t/ha)*	
	yala 86	*maha 86/87*	*yala 86*	*maha 86/87*
N_1K_1	2.54 bc	2.96 cd	4.51 a	2.82 c
N_1K_2	2.30 cd	2.35 e	4.89 a	3.55 ab
N_1K_3	2.69 ab	2.51 de	4.21 a	4.07 a
N_2K_1	2.19 d	2.93 cd	4.25 a	3.28 bc
N_2K_2	3.09 a	3.48 bc	4.42 a	2.77 cd
N_2K_3	3.05 ab	3.32 bc	4.55 a	2.90 c
N_3K_1	3.04 ab	4.18 a	2.83 b	1.24 b
N_3K_2	2.97 ab	3.60 ab	2.86 b	2.08 e
N_3K_3	3.13 a	3.07 bcd	3.69 ab	2.26 de
CV (%)	9.4	10.6	1.6	9.7

Values followed by a common letter is a column are not significantly different at 5% level of probability using Duncan's Multiple Range Test; Disease incidence score: 1 = Nil; 2 = Very low; 3 = Moderate; 4 = Severe; 5 = Very severe

Fertilizer levels: N_1K_1 = 65 kg N and 65 kg K_2O per ha
N_2K_2 = 130 kg N and 130 kg K_2O per ha
N_3K_3 = 195 kg N and 195 kg K_2O per ha

Seath rot

The causal organism formerly known as *Acrocylindrium oryzae* is now renamed *Sarocladium oryzae* Sawada. The most typical symptoms of the disease are the non-emergence of the panicle and a greyish-brown rot on the uppermost leaf sheath that encloses the panicle. Infection takes place through stomata and wounds, and the most infected plants are those infested with stem borers. An epidemic in the Pussellawa area in 1984 caused a near total yield loss. In other areas, the disease has been reported, but the damage has not been extensive.

Recent studies by Mithrasena (1989), on the biology of the fungus have revealed the growth and sporulation conditions best suited for the fungus. The best temperature for sporulation on the host medium was found to be 25±2°C. High doses of N in the form of urea has also enhanced the disease development. Low pH values were also found to favour the growth and sporulation of the fungus. So far, no resistant varieties have been found in Sri Lanka. Fungicidal evaluation in petri plates by Mithrasena (1989) has shown that at low concentrations, benomyl 50% can considerably inhibit the growth of the organism. Sheath rot fungus is seed-borne, and the best means of control is by the use of clean seed.

Leaf and grain spotting

This is caused by a complex of fungi which include species of *Helminthosporium, Curvularia, Trichonis, Fusarium, Nigrospora* and others. While leaf spotting is mostly caused by *Helminthosporium,* grain discolouration often is a result of the combined effect of both *Helminthosporium* and *Curvularia.*

Spotting of grains causes poor germination which results in a poor stand. Seedlings that germinate are weak, and their leaves become infected. Infection of leaves causes a reduction in the photosynthetic area, and also serves as a source of inoculum that would re-infect flowers and the developing grain. The result is a substantial loss in grain quality. During parboiling, the intensity of discolouration of the grain is increased, and this further reduces the quality. Observations made at Bombuwela were that up to 10% weight loss could be attributed to this disease. Wickramasinghe (1983) has indicated that more spotting occurs at low nitrogen levels, and that there are relationships between leaf and grain spotting, and between grain and kernel spotting. Further studies carried out by the same author have indicated that the flower opening time had a direct bearing on grain discolouration. He also reports having isolated an antagonistic microorganism against most of these grain spotting causal fungi.

Virus diseases

Of the virus diseases reported, only tungro has caused some damage even though its occurrence is not frequent. In maha 1983/84 in the Hambantota district, severe yellowing was reported, and some plants when tested were found to be infected with the tungro virus. However, it could not be ascertained whether the cause of the problem was tungro alone or not. Other viruses reported were ragged stunt, grassy stunt and what appeared to be orange leaf.

Leaf yellowing

This has been reported at various crop growth stages from different parts of the Island. Several factors such as nutrient deficiency (especially nitrogen), occurrence of tungro virus, deep transplanting or residual effects of chemical application may be involved either separately or in combination.

Grain sterility

Grain sterility is an abnormality for which a single causal factor cannot be pinpointed. The Gampaha district, where it is very often reported, is prone to bad weather conditions at the flowering stage. It is possible that bad weather could cause the grain emptiness. Farmers speculate that heavy blowing results in empties in July. This therefore, is termed 'Ehala Pussa' by them. However, studies by Kobayashi and Nugaliyadde (1988) have indicated the cause to be damage by paddy bug or stink bug of *Leptocorisa* spp. and other species.

FUTURE STRATEGIES

Future strategies for the control of most of these diseases lie in an integrated effort of the plant breeder, plant pathologist and agronomist. Breeding for disease resistance has to be considered a priority. The major task of the plant pathologist should be to systematically study the nature of host resistance and interaction between the plant and the pathogen. This will enable to find suitable donor varieties. The task of the plant breeder is to incorporate resistance into the new varieties. The agronomist should develop an appropriate package of cultural and management practices to prolong the durability of resistance while keeping the occurrences to a minimum. Use of fungicides should be the last resort for disease control.

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