EPIDEMIOLOGY AND LOSS OF RICE, WHEAT AND PEARL MILLET CROPS DUE TO DISEASES IN INDIA

S. Nagarajan

ABSTRACT

Nearly 64 MT of rice from 41 M ha is affected by various diseases. In 8 years 7 epidemics of blast occurred in 4 states. Endemic pockets, nature and recurrence of the disease are well known. There is a linear relationship between severity rating and realized yield. Y = 4306.0 - 67.7 x, where Y = estimated yield and x = the % terminal blast severity. Operational research and rice miller-sponsored IPM in selected areas, curtailed loss. Tricyclazole (Beam 0.6 g/l) as foliar spray and seed treatment with Pyroquilon (Fongorene 50 WP 4 g/kg) or Beam (4 g/kg) proved useful.

Information on bacterial blight of rice that caused epidemics in Punjab and Haryana in 1980 and 1981, Karnal bunt of wheat over North West India and 1984-85 epidemic of green ear of pearl millet in Rajasthan is presented.

Rice blast

Rice grown over 41 M ha with a production of 65 MT, suffers from a large number of diseases. By the year 2000 AD projected demand will be in the order of 97 MT, indicating the major concern about increasing the rate of production from the present 3.03%, and adding stability against pests and diseases.

In many parts of India rice monoculture is common and all stages of the crop and collateral hosts are available in abundance. Therefore, the blast pathogen (*Pyricularia oryzae*) always survives, but at varying inoculum threshold levels. The coexistence of susceptible varieties and the weather conditions at the appropriate time trigger the epidemic. Naturally, only isolated epidemics occur (100 × 100 km area) and seldom assume the proportion of a pandemic. The time of blast outbreak in the endemic area varies from July-September in the Kashmir Valley to November-January in Tamil Nadu (Table 1). Blast occurred seriously during 1980 in Himachal Pradesh, 1983 and 1986 in parts of Andhra Pradesh, many areas of Tamil Nadu during 1983 and 1987, Haryana in 1986, etc. (Fig. 1).

Normally, rice varieties yield 2,00-2,500 kg/ha under farmers' field conditions, wherein, a yield reduction of 7.7 % is estimated to occur due to blast. However in the experimental plots it ranged from 4.5 to 43.0 % depending on the variety and the time of onset of the epidemic.

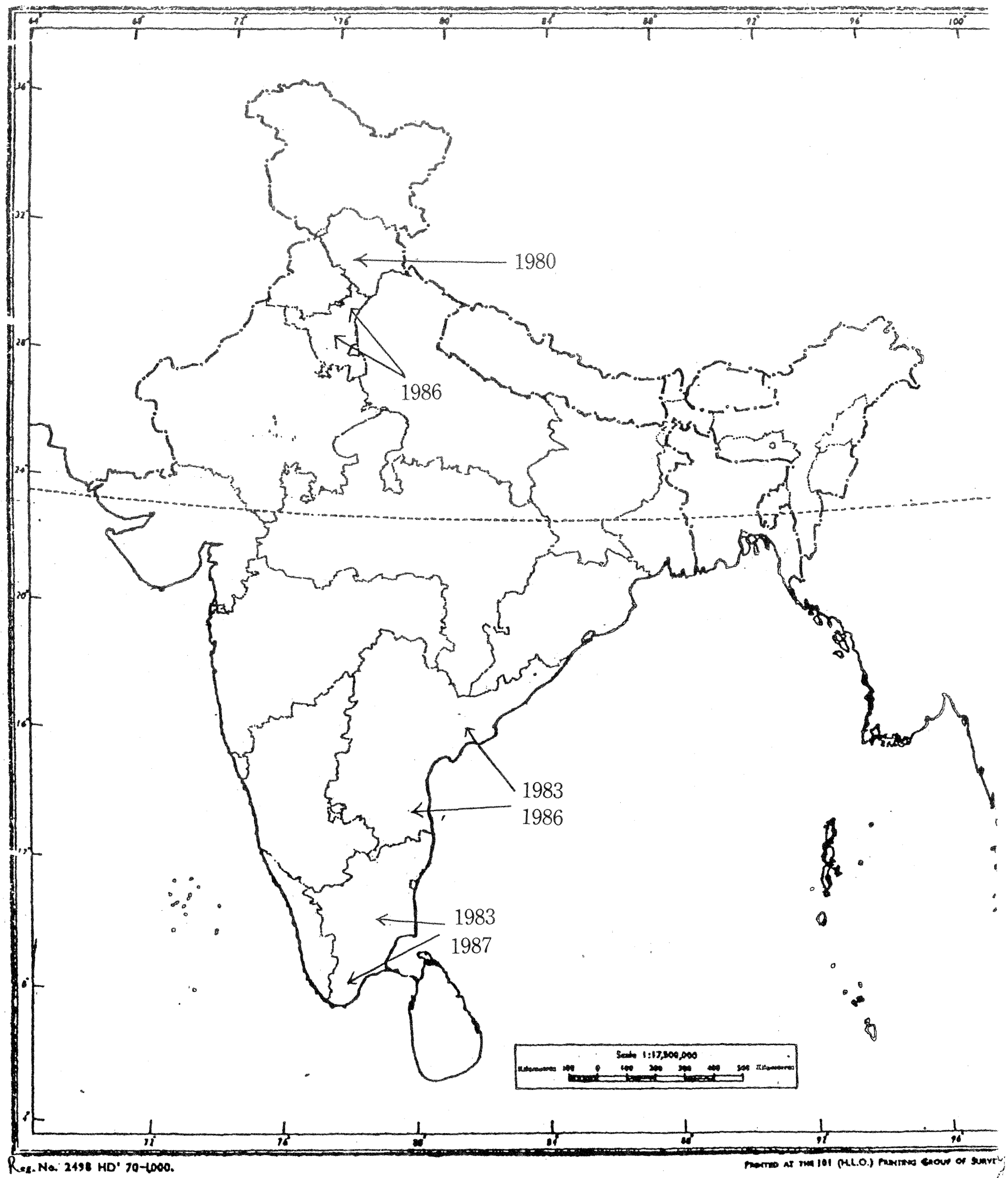
1 Relationship between severity and yield loss

Rice variety IR 50 is highly susceptible to blast and yielded only 850 kg/ha, while the blast resistant IET 5742 variety yielded 4,250 kg/ha. When various genotypes possessing different levels of blast resistance were regressed against yield (Fig. 2a), there was a linear relationship (r = -0.9124) indicating a high degree of fit.

$$Y = 5510.85 - 579.50\,x \qquad \text{.. Eq.1}$$

where, Y = Predicted yield, and
x = Blast severity score for the field in the 0-9 scale.

* Assistant Director General (Plant Protection), I.C.A.R, New Delhi — 110 001, India.



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The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Bhutan is a state in special treaty relations with India.

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Fig. 1 Epidemics of rice blast during the last eight years.

Table 1 Indian states, blast endemic areas and period of epidemic occurrence

State	Endemic districts	Period
Jammu and Kashmir	Anantnag	July-Sept.
Orissa	Cuttack, Ganjam, Koraput	July-Aug. Sept.-Dec.
West Bengal	Darjeeling, Cooch Behar	Aug.-Sept.
Himachal Pradesh	Kangra	Aug.-Sept.
Uttar Pradesh	Nainital	Aug.-Oct.
Manipur	Central	Aug.-Oct.
Meghalaya	West Khasi hills	Aug.-Oct.
Assam	Nowgong, Kamrup, Goalpara	Aug.-Oct.
Tripura	West, South	Aug.-Oct.
Bihar	Ranchi, Hazaribagh	Aug.-Oct.
Karnataka	Mandya, Coorg	Aug.-Oct.
Madhya Pradesh	Raipur	Sept.-Oct.
Kerala	Palghat, Kuttanad	Sept.-Oct.
Maharashtra	Pune, Ratnagiri, Kolaba, Parbhani	Sept.-Oct.
Gujarat	Kheda	Sept.-Oct.
Andhra Pradesh	Vishakapatnam, Guntur, Nellore, Chittor, Anatpur, Kurnool, Nizamabad	Sept.-Jan.
Tamil Nadu	Thanjavur, Coimbatore	Nov.-Jan.

Source: DRR, Hyderabad, India.

The equation indicates that 5,511 kg/ha is the attainable yield where a yield reduction of 479.5 kg occurs irrespective of genotype for every unit increase in blast severity.

Reddy *et al.* (1988) using 3 sprays of Bavistin created different blast severity levels on IR 36 and IR 60 in an operational research project over an area of 190 ha. When the blast severity recorded in % (both neck and leaf blast) was regressed against yield again a very high fit was noticed (r = 0.9427) where,

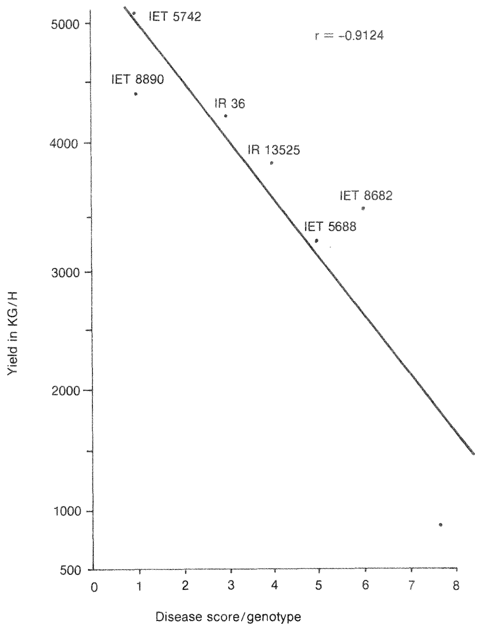
$$Y = 4306.4 - 67.7\ x \qquad \text{.. Eq. 2}$$

where, Y= Predicted farm yield of IR 50/IR 36
x = Severity rating in %.

The attainable farm yield of IR 50/IR 36 is 4,306 kg/ha and a drop of 67.7 kg in yield occurs for every unit increase in disease severity (Fig. 26). Both equations 1 and 2 show a negative linear relationship between disease severity and yield, and we have reasons to believe that equation 1 is more realistic for yield prediction.

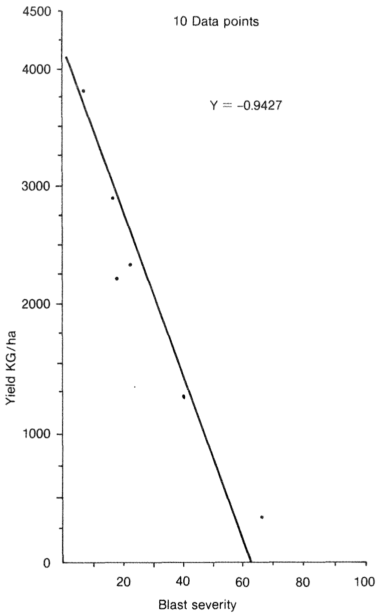
2 Chemical control

Optimum economic spray schedule studies indicate that the application of Bavisti at tillering followed by two sprays of Dithane M-45 at the panicle initiation and flowering stages are most suitable. The effect of Topsin-M and Edifenhos was comparable to that of Bavistin. The granules of Corotop, Kitazin and Chlobenthazone were highly effective while Fongoren 50 WP gave protection



Based on data of Reddy *et al.* (1987).

Fig. 2a Blast severity over yield.



* Model development based on the data of Reddy *et al.* (1987).

Fig. 2b Linear relationship between rice blast severity and realized yield of IR 50 and IR 60 under good agronomic practices — ORP data*.

up to 50 days. Tricyclazole (Beam 0.6 g/ℓ) as foliar spray and seed treatment with Pyroquilon (Fongorene 50 WP ® 4 g/kg) or Beam (4 g/kg) proved useful. Such a treatment kept the disease below the economic threshold till crop maturity (Anon., 1988).

3 Blast control campaign

After the 1983 epidemic in Haryana the milling industry came to the rescue during the 1985-86 epidemics. Blast information bulletins in local languages were distributed through the grain commission agents. In addition, crop health monitoring team intensively surveyed the area. This was backed up by providing the farmers with power sprayers at their farm, free of rental charges. A fungicide (Hinosan or Bavistin 0.1 %) spray was extended to cover both leaf and neck infections based on surveillance data.

In Tamil Nadu also, for rice, observations from fixed plots were recorded and a surveillance —threshold based prediction system has been developed and used since 1987. But developing a quantitative model for disease prediction will be more realistic.

Bacterial leaf blight (*Xanthomanas oryzae*) epidemic in Punjab

The BLB epidemic was of moderate severity during 1975, 1976, 1978 and 1979 in the Amritsar, Gurdaspur, Kapurthala, Hoshiarpur and Forozpur districts. The disease was severe during 1980, 1981 and 1983, being endemic in these districts of Punjab. In the Amritsar district 1/3 of the planted area or 66,000 ha and nearly 2,000 ha in Jullundhur were seriously affected by BLB. In more than 4,000 ha the crop was totally ruined by the *Kresek* phase (Reddy, 1980). In such fields yield loss in the variety Jaya was 65-93% and 86% in PR 106. Irrespective of the severity level, PR 106 registered greater proportions of crop loss compared to Jaya. Due to the widespread occurrence of the *Kresek* the loss figures were higher even as compared to earlier reports (Reddy *et al.*, 1979).

The number of sterile florets/head (x_2), BLB severity in % (x_1) and yield data given by Reddy (1980) for the variety PR 106 indicate a linear relationship ($R = 0.874$) where, yield (Y)

$$Y = 21.71 - 0.026\ x_1 - 0.03\ x_2 \qquad \text{.. Eq. 3}$$

But there seems to be a lesser fit with Jaya, the tolerant variety. Therefore, loss estimation formulae specific for groups of varieties need to be developed.

1 Reasons for BLB outbreak

Till a decade ago, rice cultivation was less popular in Punjab and now sowings are done almost a month earlier than the recommended date. The flowering and other stages coincide with the heavy monsoon downpour. As rice is sown prior to the severe summer, inoculum surviving on seed and other sources readily infect the seedlings in the nursery. Though the inoculum is said to be seed-borne, in Punjab it has been observed that severe blight develops even in seed-treated plots. The level of crop diversity during the rainy season has narrowed down. Maize, pearl millet, and some pulses have been replaced by the more remunerative rice crop, and the continuous rice culture may have contributed to the severe BLB development.

2 Weather in relation to BLB

The rainfall pattern for 1977 to 1980 of the Amritsar district indicates that both the amount and the number of rainy days during July-August is important (Table 2). Less than normal precipitation is invariably coupled with the increase of the mean maximum temperature by 1.5 to 2°C. As a result, disease development is curtailed, and during favorable years the disease flares up rapidly leading to severe epidemics. The *Kresek* stage develops in July-August when the temperatures are high, while the late plantings invariably escape serious infection due to the reduced number of rainy days and maximum ambient temperature being lower than 30°C by 1.5 to 2.0°C.

Table 2 Rainfall and temperature at Amritsar (Punjab) for four different years during the rice growing months

Period	Total rainfall (in mm)				Total rainy days				Mean maximum temperature			
	1977	1978*	1979	1980	1977	1978	1979	1980*	1977	1978	1979	1980
May	6				1				28.0	33.2	N.A.	32.2
June	48	97		90	4	6		4/6	30.6	32.5	N.A.	32.9
July	176	308	154	268	8	14	9	9/15	30.1	30.0	30.1	29.7
August	107	336	12	180	5	7	2	6/7	29.7	29.7	30.7	29.9
September	80	56	90	30	4	3	6	4/7	27.5	28.7	28.5	28.5
Total	417	797	256	568								

Source: Reddy (1980).
*Subscript denotes wet days
N.A. Œ Not available
1978 and 1980 are epidemic years

Karnal bunt of wheat

Karnal bunt (KB) pathogen *Neovossia indica* appears at the time of threshing. It infects the developing karyopsis around flowering time. The extent of damage to the grain varies from a small black sorus on the embryonic end to the entire grain being transformed. Though yield loss may not be of consequence, even a 2-3 % infection renders the wheat product unpalatable due to the presence of dimethyl amine, in the infected kernels. The life cycle of the pathogen has been well documented by Dhaliwal and Singh (1988).

1 Differences between black point and KB

The black point or blackening of the embryonic tip of the grain is caused by a number of weak pathogens such as *Alternaria* spp., *Helminthosporium* that is often mistaken in identity with Karnal bunt. The bunt produces a sorus and when pressed releases a mass of powdery spores. The black point unlike KB does not affect the quality of the wheat product.

2 Reasons for the sudden spurt in KB

It is often felt that the cropping intensity, change in varietal pattern, agronomic practices, increased plant density, irrigation, etc. have enhanced the survival of the pathogen and increased the disease severity. As these parameters are difficult to analyse, the real cause for the spurt in KB incidence remains unknown.

Between 1976-84 a few thousand grain samples collected from procurement centres and threshing floor were studied for KB prevalence and severity (incidentally, this revealed the varietal dynamics at the farm level also). In the southern semi-arid parts of Haryana, C 306 is grown under low fertility conditions. In the North and East with assured irrigation, varieties like Arjun, WL 711 were grown under high input conditions. A similar situation existed in Punjab, parts of West U.P. also. In other words varieties under intensive management were more susceptible compared to the tall, improved C306 released in 1964, derived from a wide cross (Table 3). The tolerance that was noticed even during the very congenial epidemic years indicates that it is a host attribute (Table 3). Variety C 306 differs markedly in maximum infection and % samples infected, which indicates a narrow period of vulnerability due to which the infection is reduced.

Karnal bunt infected grains of varieties HD 2009, Sonalika, WL 711, and WL 1562 sampled during the 1987 harvest year from the northwestern states were classified into 5 grades based on the sorus type (Singh *et al.*, 185). Grade 5 indicates full transformation of the grain as a sorus. The percentage of infected grains that falls into each category was plotted. While WL 711 and HD 2009 produced more of the 4 and 5 category of sorus type, WL 1562 and Sonalika produced predominantly

Table 3 Karnal bunt infection on HD 2009 and C 306 (local) from 1976-1984 in Haryana state, India

Period	Sample No.		% samples	Infection %	
	Total	Infected	infected	Maximum	Mean
1976-79					
HD 2009	58	20	34.5	2.4	0.11
C 306 (Local)	44	8	18.2	1.2	0.08
1980-84					
HD 2009	1196	438	36.6	9.6	0.26
C 306 (Local)	315	14	4.5	1.3	0.09

(Based on source data: Singh *et al.*, 1985).

smaller sorus. Cultivation of such genotypes will, over the years, drastically reduce the inoculum load of the pathogen and will contribute to the overall reduction of the disease severity.

3 Disease prediction

Qualitative analysis indicates that low temperature and high rainfall around anthesis time are the main factors influencing KB. Various attempts to correlate the disease severity on WL 711 and HD 2009 with meteorological parameters failed. Therefore, we tried to fit a non-linear relationship between disease severity and accumulated degree days (°D).

$$Y = 93.8 - 0.385\ D + 0.0004\ D^2$$

This quadratic relationship with °D gave a multiple R value of ~ 0.5 which was the best fit that could be obtained. By refining the weather recording procedures and disease severity assessment more accurate models could be developed.

But what comes out clearly is the usage of °D in predicting the disease incidence and the non-linear relationship between them.

4 Disease management strategies

(a) Normally sown crop escapes as at anthesis time temperatures are too low, to permit high levels of infection.
(b) Breeding for tolerant varieties such as WL 1562 and HD 2285 and popularizing them over North West India.
(c) For seed production purposes spray application of either Bitertand (Baycor 70 WP) @ 0.2 % or Propiconazole (Tilt) @ 0.2 % is suggested. A new chemical dichlopentazole (S 3308 L) is highly promising.

With the integrated approach, severity of KB over the years will be considerably reduced.

Downy mildew of pearl millet

Pearl millet (*Pennisetum typhoides*) is an indispensable cereal of the dry farming system where annual rainfall ranges from 100-700 mm. More than 94 % of the 11.37 M ha is rainfed though HYVs occupy nearly 40% of the area.

Downy mildew of pearl millet (*Sclerospora graminicola*) is now the major production constraint and caused serious epidemics in 1971, 1975 and 1985. Seed contamination with oospores internally, seed-borne mycelium, and soil-borne inoculum result in the disease expression on the first and second leaf itself. As the chlorotic leaf streak spreads further the plant becomes dwarfed and may even die. The ear head is transformed partly or completely into loose green strands. Seeds collected from such heads become contaminated with oospores, and the incipient seed-borne infection and the soil-borne inoculum contribute to the perpetuation of the disease.

Table 4 Periodical roguing effect on downy mildew of pearl millet, 1976-78

Roguings (No.)	Age (days)	% plants infected 1976	% plants infected 1977	Rogued (%) 1976	Rogued (%) 1977	Grain yield (q/ha) 1976	Grain yield (q/ha) 1977
Check	Ç	53.3	52.0	0.0	0.0	17.0	16.7
1	17	27.6	22.1	27.6	22.1	20.2	21.2
2	17Œ25	18.7	17.0	46.3	39.1	14.0	14.8
3	17Œ25Œ33	7.0	Ç	53.3	Ç	12.0	

Source: AICMIP Annual Report.

Timely roguing of infected plants can reduce the initial foci of infection, if carried out early in the season. But roguing performed several times reduces grain yield substantially mainly due to the decrease in the plant density (Table 4).

Disease management approaches

Irrespective of location, pearl millet sown just prior to the onset of the monsoon is less affected by downy mildew. However the plants sown from the middle of July and thereafter recorded a very high incidence of the disease. Agronomic manipulation through the adjustment of sowings is one means of minimizing crop loss (Table 5).

Seed treatment with metalaxyl formulations such as Apron 35 SD and Ridomil 25 WP have effectively restricted downy mildew incidence (Dang and Thakur, 1985). Backed by a foliar spray of either of the chemical at 30 DAS @ 1000 ppm concentration, mildew can be totally controlled. To avoid the occurrence of resistant strains and increase effectiveness a mixture of two products (Ridomil + Maneb) as Ridomil MZ is marketted.

Table 5 Planting dates and natural incidence of downy mildew, 1975-78

Sowing	Per cent downy mildew				
date	HB 3	NHB 5	PHB 15	BJ 104	BS 1
June 25	19.7	4.2	0.7	1.0	3.2
July 5	26.4	6.0	2.7	2.1	3.8
July 15	37.6	10.0	7.1	3.7	4.4
July 25	34.6	18.5	4.1	7.2	6.1
Mean	30.1	9.7	3.5	2.3	4.4

Source: Thakur (1986).

Acknowledgement

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Discussion

John, V.T. (IITA): 1. There was a shift in the rate and magnitude of localized blast epidemics in India from 1982 onwards, whereas before that period such epidemics were seldom recorded. What is the reason for this change? 2. Your relationship studies are based on leaf blast symptoms. Would the situation be different if neck blast had been included?

Answer: 1. The increase in the intake of fertilizer, in particular nitrogen fertilizer and the change in the varietal flora (IR 36 and IR 50) may be responsible for this phenomenon. 2. The linearization that was attempted is related to the blast severity as such and not to leaf blast or neck blast separately.

Mew, T.W. (IRRI): I was told by Indian scientists that sheath blight was very important in India. Would you elaborate on this point?

Answer: Indeed sheath blight is a very important disease which occurs in all the rice-growing states in India. However though it is of concern it has not caused any serious epidemics. As BLB causes epidemics in North-West India which contributes about 6 million tons to the buffer stock, this disease was selected for the presentation.