BRIEF REPORT ON SOME IMPORTANT DISEASES OF THREE MAJOR CROPS IN CHINA

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ABSTRACT

The report will be restricted to the following diseases: i.e. bacterial lead blight (*Xanthomonas campestris* pv. *oryzae*) and blast (*Pyricularia oryzae*) of rice, scab (*Gibberella zeae*) and root rot (or leaf spot, *Helminthosporium* spp. etc.) of wheat and Verticillium wilt (*Verticillium dahliae*) of cotton.

Disease distribution, trend of occurrence, and yield losses will be illustrated in general. The pathogenicity of *X. campestris* pv. *oryzae* and *V. dahliae*, the epidemiology of rice blast and wheat scab will be discussed in detail. Defoliating type of *V. dahliae* and 8 new plants of this pathogen have been first discovered in China. Several different causal organisms of wheat root rot or leaf spot belonging to different species in different genera have been identified. Some of them have been first described in China. Environmental effect on pathogen and disease development is also analysed. Various control measures for individual diseases are introduced and corresponding emphasis is given in each case.

Rice, wheat and cotton are three important crops of great significance in China. Many diseases caused by fungi, bacteria, viruses and other pathogenic organisms frequently affect the production of these three crops. This brief report will be restricted to the following diseases, namely bacterial leaf blight and blast of rice, scab and root rot (or leaf spot) of wheat and Verticillium wilt of cotton.

Bacterial leaf blight (BLB) of rice

BLB is one of the constraints that influence considerably the yield of rice especially in case of the production of susceptible varieties. The disease widely occurs almost in all the rice-growing areas, but it brings about more severe damage along the rivers and lakes. In 1982, more than 1,300,000 hectares were affected by the disease. Yield losses in severely infected fields range generally from 10 to 20%, but complete failure in harvest occurs sometimes in individual fields (Wang, 1986; Xu, 1986).

1 Epidemic regions of bacterial leaf blight of rice

Before the 1960s, bacterial leaf blight of rice was prevalent mainly in the southern and eastern parts of China. The hsien rice varieties, or rice of indica type were more susceptible to BLB than the keng rice varieties (sinica, or japonica type) in South and Central China. The BLB has started to spread rapidly to the northern part of China since the 1960s. So far no occurrence in Xinjiang Uygur Autonomous Region, Inner Mongolia Autonomous Region, Qinhai and Gansu Provinces (Xi, 1986) has been reported.

Although the rice-growing area in China can be divided into six belts based on the cropping systems, varietal distribution and environmental conditions the epidemic zone of BLB can mainly be divided into three regions (Xu, 1986):

1) The South China double cropping area: In this area, rice is often infected in the field, and severe damage of the rice crop is due to the tropical weather conditions and frequent typhoon attacks from June to October.
2) The Central China mixed cropping region: This region stretches from Nanling (southern mountain) to Huai River. In this region the Yangtze Valley is the most important base for rice production in China. More than 25% of the total rice acreage is covered by hybrid rice. Varieties

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used in this area for the first crop are generally of the hsien type with early maturity or hybrid rice with high-yielding capacity and varieties for the second crop are usually of the keng type. BLB may occur from June till October. The situation in the southwestern China rice belt is fairly similar to that of this region.

3) The North China keng rice region: This region includes the North China, Northeast and Northwest China rice belts. The epidemics of BLB are restricted only to the period from July to August. The varieties adopted in different areas vary with the production requirements. When higher yield is stressed, disease resistance of the varieties is generally ignored. In the Guangxi Autonomous Region, there have been several outbreaks of BLB on rice during the last ten years. BLB spread widely and brought about severe yield losses. The increase of the epidemic acreage of BLB is closely related to the expansion of hybrid rice (Shen, H.H., personal communication) (Table 1).

Table 1 Acreage of rice infected with BLB and acreage of hybrid rice in Guangxi Autonomous Region

Year	1977	1978	1983	1985
Hybrid rice area (kha)	240	421	210	310
BLB area (kha)	56	132	60	81
Yield losses (kt)	400	924	350	400

2 Virulence of pathogen

Xu and Fang (1986) have tested the virulence of more than 300 isolates of this pathogen, which were collected from five rice belts in China. On the basis of the reaction to differential host varieties, this pathogen may be divided into five groups in China (Table 2).

In general, most of the isolates from South China appear to show a higher virulence and belong to groups 2, 3 and 4, while those from the northern part of China show a lower virulence and belong to groups 1 and 2.

A large number of short-stalk, high-yielding varieties adapted to various rice-growing areas showed in general a lower resistance to BLB, such as Ai-Nan-Zao, Yuan-Fen-Zao, Jin-Gang 30, Nanjing 11 and Gui-Chao 2. Moreover, due to the interest in high-yielding potential, a large number of hybrid rice varieties have been widely grown in South and Central China. Unfortunately, all these hybrids had been found to be quite susceptible to BLB, such as Nan-You 2 and 3, San-You 2 and 3, etc. As a result of the active introduction and rapid spread of high-yielding susceptible rice cultivars or hybrids, BLB has become one of the most serious diseases of rice in China (Xu, 1986).

Table 2 Virulence groups of *X. campestris* pv. *oryzae* in China

Group	Isolates	Reaction on differentials				
		Jingan 30	Tetep	Kograku	Nangeng 15	IR 26
1	OS-14	S	R	R	R	R
2	Ks-6-6	S	S	R	R	R
3	Ks-1-21	S	S	S	R	R
4	OS-86	S	S	S	S	R
5	OS-88	S	S	R	S	R

3 Effect of climatic factors

The optimum temperature for the occurrence and development of BLB is about 26–30°C. The disease can be inhibited or stopped when the temperature is lower than 20°C or higher than 33°C. The rainfall and humidity of the air affect the transmission, infection, propagation of the pathogen. Typhoon is another important factor affecting BLB outbreaks. It had been reported (Wang, 1986) that in the eastern part of China, when the number of rainy days exceeded 8 in the last ten days of June, the ripened rice was severely infected; when there were more than 20 rainy days from early July to August 20 accompanied with an average atmospheric temperature lower than 30°C, the disease occurred on varieties with intermediate maturity. The occurrence of BLB on rice with late maturity is closely related with the number of rainy days and the frequency of typhoons from July to August. When there are more than 6 typhoons, a severe BLB epidemic can be expected.

Rice blast

Blast is another important and widely distributed disease of rice. It occurs almost in all the rice-growing areas in China. The severity of the disease varies annually with the climatic conditions of each area (Table 3) (Wang, 1986). Severe epidemics of blast are recorded when lower temperatures and continuous rainy days occur in the heading stage of rice. Yield losses which generally range from 10 to 20% may reach 40% or 50% in case of severe occurrence.

Table 3 Acreage and yield losses associated with rice blast in some provinces

Year	Provinces	Rice blast area (kha)	Yield losses (kt)
1980	Zhejiang	330	250
1980	Jiangsu	245	85
1981	Fujian	133	150
1981	Jiangxi	20-130	/
1985	Jiangxi	260 (leaf rot) 130 (panicle rot)	350-420

1 Overwintering and source of primary inoculum

It was shown in the 1950s that diseased straws and seeds are the principal overwintering organs. Recently it has been reported in Zhejiang that pathogens borne on *Digitania sanguinalis* and *Panicum repens* plants may infect rice also (Wang, 1986).

2 Pathogenic races

Seven varieties, Tetep, Zhenlong 13, Sifeng 43, Dongnong 363, Kanto 51, Hejiang 18, Ligiang-sintuanheigu were used as the differential varieties in China and 828 isolates from monoconidial cultures collected from 23 provinces and autonomous regions were identified on the above-mentioned differential varieties. The results indicated that the isolates can be divided into 7 groups with 43 races. Among these races, the Zhong Gl race is the most widely distributed with a high frequency of appearance and this race may be considered as a dominant race in China. The composition of the races in the indica rice-growing area and japonica-indica rice mixed-growing regions in South China is much more complicated than that in the japonica rice-growing region in North China. It seems that the indica races (with S reaction on indica differentials) in the South are much more virulent than those in the North.

However, the pathogens from the southern growing area, Yangtze Valley and northern as well as northeastern growing area showed a strong, intermediate and weak pathogenicity, respectively. The appearance of a new virulent race may cause the loss of resistance of a variety.

3 Epidemiology

Many studies (Wang, 1986) have shown that the prevalence of rice blast is conditioned by the effect of temperature and rainfall on the pathogen growth and the relation of plant age to susceptibility, i.e. when the plum rains (the rainy season, usually occurs in June and July, in the middle and lower valleys of the Yangtze River) coincide with the susceptible stage of rice plant, an epidemic is generally observed. It is also reported that a combination of mid-summer plum rain and autumn low temperature (20°C, lasting more than 3 days) may lead to the prevalence of neck rot and panicle rot in early maturing rice and leaf rot and panicle rot in late maturing rice.

4 Control of BLB and blast of rice

Use of resistant cultivars is the principal method for disease control in addition to cultivation practices and chemical control (Wang, 1986; Xu, 1986).

1) Resistant cultivars

In the past 10 years, a number of high-yielding varieties with good resistance to BLB and blast were adopted in various rice areas, such as Jingling 57, Yangdao 2 in Jiangsu Province, Xiushiu 48 in Zhejiang Province, Xiangaizao 3 and Xiangzhou 6 in Hunan Province, Bohuizhan 1 in Guangdong province, Sanfu 63 and Shuanggui 36 in Sichuan Province, etc.; in addition, Erjiufeng, Chuanzhi 2, Chuanzhi 3, Zheli 1, Jiahu 5, Hojiang 20, Binxu and Hsiengou 36 are resistant to rice blast and Yankeng 2, Nankeng 11 Nankeng 35 are resistant to BLB only.

2) Cultivation practices

Raising healthy and strong seedlings in nurseries is very important. Limited application of nitrogen fertilizer is also a way to avoid serious outbreaks of BLB and blast. Controlled irrigation has also been used as a means for reducing BLB and blast severity.

3) Chemical control

For technical reasons, it is difficult to spray fungicides in the whole paddy field. It is suggested that seed treatment and sporadical spraying of disease centers may be the best choice.

Wheat scab

Scab, root rot and head blight of wheat occur widely in China. Wheat scab is particularly severe in the middle and lower Yangtze Valley.

Chen and Wang (1982) studied the pathogenic species of wheat and barley in Zhejiang Province and indicated that *Fusarium graminearum* predominated in distribution, accounting for 93.9% of the total samples ocllected. Other species ranging in decreasing order of percentage were: *F. moniliforme* (2.4%), *F. acuminatum* (1.2%), *F. lateritum* (0.6%), *F. semitectum* (0.2%), *F. fusarioides* (0.2%), *F. oxysporium* (0.2%), and *F. oxysporium* var. *redolens* (0.2%). Difference in virulence of the 12 species showed that *F. graminearum* was rated as virulent to wheat. *F. acuminatum*, *F. tricinctum* and *F. avenaceum* virulence was rated medium, while the virulence of the other species was rated weak. Zheng (1986) reported that *F. graminearum*, *F. campoceras* and *F. sulphureum* showed a higher virulence in Fujian Province. Xu *et al.* (1986) found differences in the virulence of isolates of *F. graminearum* from regions with different severities of the disease. Isolates from the epiphytotic part of China, e.g. Jiangsu Province, were notably more virulent than those from Heilongjiang Province and northwestern parts of China where scab disease occurred less frequently.

1 Epidemiology and disease forecast

The prevalence of wheat scab (head blight) is conditioned by the relation of intermittent drizzles to the blooming stage of wheat. There are five epidemic types of the disease:

1) Early occurrence type: It is characterized by excess rainfall and high temperature in the early growing season. Different inoculum generally appears. The disease develops most explosively from late April to early May, with a high possibility of severe epidemics.
2) Late occurrence type: There is less rain with a lower temperature in the early growing season,

but more rain appears in the late season. As the inoculum matures later, the disease develops most explosively from mid-to late May, usually causing an intermediate level of disease epidemic.

3) Whole season severity type: It is rainy at the heading and blooming stages with higher temperature in the early season. The inoculum matures earlier. Severe disease occurs throughout the growing season.
4) Less rain limitation type: There is less rain at the heading and blooming stages. Sufficient inocula are absent and seldom does the disease occur.
5) Low temperature limitation type: The disease usually does not occur due to the low temperature, although the precipitation may be abundant. There are two kinds of forecast of wheat scab disease, i.e., mid-term forecast and short term forecast.
   a Mid-term forecast: This type of forecast is aimed to predict the epidemic level (low, intermediate or high) and type 20–30 days before the heading stage depending on the time of inoculum appearance and amount (perithecia, asci and ascospores). The mid-term and/or long term synoptic forecast is based on the estimates of heading and flowering time of wheat and refers to the data of disease occurrence over the years.
   b Short term forecast: It will provide a more exact prediction of the time and severity of the disease occurrence 2–3 days before the outbreak. This could be achieved on the basis of a mid-term forecast and by further examining the factors affecting the disease epidemic, e.g. more precise determination of the growth stage of wheat, amount of inocula and the trend of weather. For both mid-term and short term disease forecasts, the precision relies to a great extent on the accuracy of the synoptic forecast. Unfortunately, the synoptic forecast at present is not very accurate, which, in turn, affects undoubtedly the accuracy of the disease forecast. As a matter of fact, great progress in the forecasting of wheat scab disease has not been made in recent years in China.

2 Control

1) Breeding and use of resistant varieties: Although, hitherto, no immune or highly resistant varieties have been selected, some varieties with moderate resistance to the disease have been cultivated in recent years, such as Yangmai 4 and Yangmai 5, which are now popularly used in the lower Yangtze Valley of China (Xu, 1986).
2) Application of fungicides: Spray of carbendazin and thiophenate in critical time with reference to the disease forecast usually at heading and flowering stages may bring about good results. This kind of chemical control is now commonly accepted in most of the affected areas in China. It is worth mentioning that good results of spraying depend again on the accuracy of the disease forecast.

Wheat common root rot

Wheat common root rot (or leaf spot) disease mainly occurs in North China (Beijing Agricultural University, 1982). In the past 10 years, this disease has led to more yield losses in Guangdong Province and has become one of the main constraints for wheat production in that area (Wu, 1983). In Jiangsu Province, widespread leaf spot is also observed in the wheat-growing area.

1 Causal organisms

Many studies indicate that the pathogenic fungi causing wheat common root rot include *Bipolaris sorokiniana, Exserohilum monoceres, Curvularia lunata, C. oryzae, Alternaria alternata, Fusarium graminearum, F. sambucinum, F. semitectum, Trimmatostroma* sp. *Rhizoctonia* spp. and *Nigrospora* sp. Among them, *B. sorokiniana* is the major pathogen which exhibits a strong pathogenicity to wheat and about 80% to 90% of plant infection is caused by this fungus (Zhang, 1985).

Our study showed that the causal organisms of leaf spot are *Bipolaris sorokiniana* (43%), *Drechslera tere* and *B. bicolor* (1 %), *Alternaria alternata* (46%), *Epicoccum nigrum* (10%). In addition to the above-mentioned 5 species, 5 more species have been isolated and identified from wheat seeds (as shown in Table 4).

Table 4 Isolates from leaves and seeds of wheat

Species	From leaves	From seeds
Bipolaris sorokiniana	43%	33.2%
Dreschslera tere	1%	1.3%
Bipolaris bicolor	1%	3.5%
Alternaria alternata	46%	54.1%
Epicoccum nigrum	10%	4.4%
Bipolaris cyndodontis	/	0.9%
Exserohilum rostratum	/	0.4%
Bipolaris urochloae	/	1.3%
Curvularia inaequalis	/	0.4%
Curvularia eragrostidis	/	0.4%

2 Effect of environmental conditions

There are many factors affecting the occurrence of wheat root rot (or leaf spot). For the cultivars susceptible to *B. sorokiniana*, temperature, high humidity and sufficient inoculum are the principal factors. The infected seeds are found to be the major source of primary inoculum in South China.

3 Control

Use of healthy seeds has become an essential method for the prevention of wheat root rot in Guangdong Province. Seed treatment with hot water or fungicides i.e. Dithane M-45, Bavistin, etc. was effective in reducing the incidence of the disease. Presently cultivars showing not only high yield but also resistance to root rot (or leaf spot) disease are not available. But varieties with different levels of resistance do exist. For example, some cultivars grown in Northeast China are resistant to root rot. Thus it is considered that the development of high-yielding and resistant cultivars through recombination breeding may be promising.

Verticillium wilt of cotton

Verticillium wilt of cotton has spread rapidly in the cotton-growing areas of South China since 1979, resulting in severe losses in cotton production. For instance, the loss of lint cotton in 1980 reached more than one hundred thousand tons. The disease occurred in Jiangsu Province only sporadically before the late seventies. However, the diseased acreage grew year by year after 1979, and reached fourteen thousand hectares in 1982, involving 26 counties of the province.

1 Causal organism

The causal organism of cotton Verticillium wilt in China is *V. dahliae*. No *V. albo-atrum* has been found hitherto in China despite its dominance in many areas in the world. Three isolates of *V. nigrescens* have been obtained from cotton plants grown in Jiangsu (Lu, 1983; Wang and Lu, 1987). Their weak parasitism suggested that these isolates may not be important to epidemics of the disease but may be aging pathogens.

2 Virulence of the pathogen

The pathogenicity of 83 isolates of *V. dahliae* from Jiangsu Province was tested during the period

1982–1985 (Lu, 1987). The results indicated that 13 isolates caused severe defoliation (counts for 15.7%) and were distributed in Nantong and Changshu only. There were 45 isolates which caused leaf blight without defoliation (54.4%) and 25 isolates which caused yellow blotch (30.1%). These two types with intermediate virulence and mild virulence which did not cause defoliation were distributed widely in various cotton-producing areas in Jiangsu Province. The defoliating type of *V. dahliae* Kleb. was first reported by us in China.

3 Host range

V. dahliae has a very wide host range. In addition to the reported 250 species and 38 families, 8 more new host plants were identified including *Armoracia rusticana, Hibiscus manihot, Lawsonia inermis, Apocynum venetum, Cercis chinensis, Stevia rebaudianum, Juglans mandshurica* and *Astragalus* sp.. The wide host range does not facilitate disease control (Wang, 1987).

4 Effect of climatic factors on disease development

Two peaks of disease appearance are generally observed during the cotton-growing season. The first is in mid-July, and the second in September. The development of wilt disease and the appearance of the peak depend upon the climatic conditions. The disease development is promoted by an average temperature of 24–27°C in a ten day period and is inhibited when the temperature exceeds 27°C. Therefore the time of appearance and duration of high temperature (27°C) are the two important factors affecting the annual severity of the disease. The rainfall amount and the number of rainy days especially from July to August, affect the severity of the disease directly (Yao, 1986).

5 Varietal resistance

To date, a number of resistant varieties (or lines) have been obtained on a nationwide scale. In 1982–1985, a large number of cotton varieties or lines collected from different provinces of China were tested for seedling resistance to several types of *V. dahliae* (Lu, 1985) differing in virulence. It was found that 32% of the tested cotton varieties were highly resistant, 27% showed an intermediate level of resistance, and only 26.9% were susceptible to the non-defoliating type of *V. dahliae*. As for the response to the defoliating type, highly resistant and resistant varieties accounted for 5.3% and 8.85, respectively. Susceptible varieties accounted for 77.9%. Fortunately, as the defoliating type of *V. dahliae* is uncommon in China, the resistant varieties can still be used.

References

1) Abstracts of 1981 Meeting of Chinese Plant Pathological Society, Chinese Plant Pathological Society Press, p.24.
2) All China Co-operation of Research on Physiological Race of *Pyricularia oryzae*, (1980): Research on Physiological Race of Rice Blast Fungus in China, Acta Phytopathologica Sinica, 10 (2) 71–82.
3) Beijing Agricultural University (1982): Field Crop Diseases. Agricultural Press. pp.113-138.
4) Chen Hongkui and Wang Gongchen (1982): Studies on *Fusarium* species infecting spikes of wheat and barley in Zhejiang Province. Acta Phytopathologica Sinica, 12 (3) 1–12.
5) Li Kechang (1978): Wheat scab disease and its control. Shanghai Science and Technology Press.
6) Lu Jiayun *et al.* (1983): Studies on differentiation of the *Verticillium dahliae* Kleb. in Jiangsu Province. Journal of Nanjing Agricultural College, 1983, (1) 36–43.
7) Lu Jiayun *et al.* (1985): Seedling test for resistance to *Verticillium dahliae* Kleb. of several cotton varieties. Journal of Nanjing Agricultural University, 1985, 59–65.
8) Lu Jiayun *et al.* (1987): Distribution of different virulence types of *Verticillium dahliae* Kleb. in Jiangsu Province. Acta Phytophylacica Sinica, 14, (4) 221–224.
9) Third Congress of Chinese Society of Plant Pathology (1985): Abstract of papers. pp.99–100.
10) Wang Faming (1986): Epidemiology and control of three important rice diseases. (Unpublished).
11) Wang Kerong and Lu Jiayun (1987): Identification and pathogenicity determination of isolates of

Verticillium nigrescens Pethybr., Journal of Nanjing Agricultural University, 1987, 59-62.
12) Wang Lixin, Lu Jiayun *et al.* (1987): Identification of the causal organism of Verticillium wilt disease on different plants. Journal of Nanjing Agricultural University, 1987, 36-40.
13) Wu, B.C. and Le, Y.G. (1983): An investigation on the sources of primary inoculum of wheat common root rot and comparison of methods of counting conidia soil in Guangdong. Journal of the South China Agricultural College, 1983, 88-96.
14) Xu Yonggao (1986): Techniques for control of wheat scab disease with fungicides, Local criterion of Jiangsu Province DB/3200 B 16-01-86.
15) Xu Zhigang and Fang Chongtah (1986): Breeding of rice resistant to the bacterial leaf blight. (Unpublished).
16) Yao Yaowen *et al.* (1986): Studies on the relationship between the fluctuating incidence of cotton *Verticillium* wilt and meteorological factor in cotton growing area of the Yangtze River Valley. Scientia Agricultura Sinica, 1986, (3) 59-64.
17) Zhang Jingchun *et al.* (1985): A survey of five species of pathogenic fungi of wheat root rot in Heilongjiang Province. Institute of Plant Protection, Academy of Agricultural Sciences, Heilongjiang Province.
18) Zheng Yuanmei *et al.* (1983): Study on pathogenic species and forms of wheat scab fungi in Fujian Province. Acta Phytopathologica Sinica, 13, (2) 51-59.

Discussion

Crisp Jungklaus, S. J. (German Federal Republic): Which fungicides are used for wheat scab control?

Answer: Carbendazin and Thiophenate are used in critical situations. However since sprays are not easily performed in the field, there is a tendency to use resistant varieties.

Selvapandiyan, A. (India): What are the symptoms observed when cotton plants are infected with Verticillium wilt?

Answer: The symptoms shown reflect the pathogenicity of the causal agent. Severe defoliation is caused by the most virulent isolates while leaf blight and yellow blotch correspond to a moderate and mild level of virulence, respectively. In China presently strains with moderate and mild virulence occur most commonly while the strains with the strongest virulence are observed in the Guangzhou province only.

Uritani, I. (Japan): 1. How important is the post-harvest loss of rice in storage, in particular in the southern part of China? How do you store rice? 2. Sweet potato is the 5th most important crop in the world in terms of yield. I have heard that a large quantity of sweet potato is produced in China. Could you indicate which are the most important diseases affecting this crop before and after harvest?

Answer: 1. There are many diseases affecting rice after harvest in storage resulting in important losses. 2. In China potatoes are mostly cultivated in the northern part of the country and they are used as vegetables. The main diseases are as follows: 1. Black spot (*Ceratocystis* sp.); 2. Wilts (*Fusarium* sp.), 3. Root rot (*Rhizopus* sp.); 4. Dry rot (*Fusarium* sp.); etc. Also nematode diseases are important as well as diseases caused by *Pseudomonas solanacearum*.