Cultivating biodiversity for disease control, a case study in China

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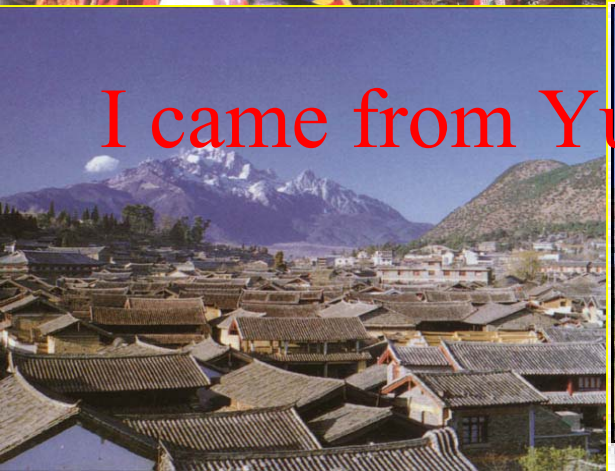
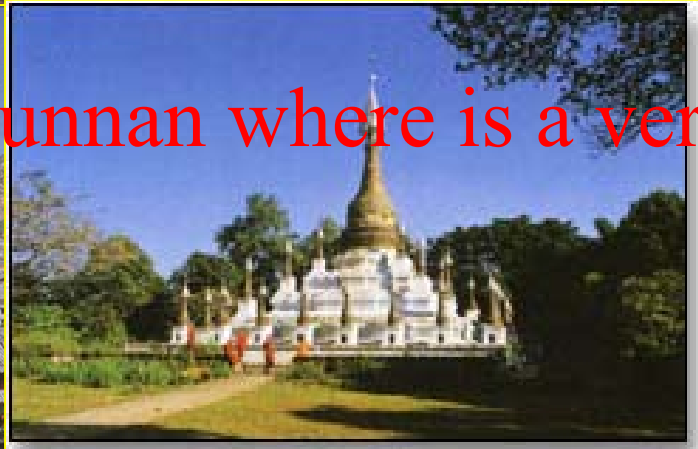
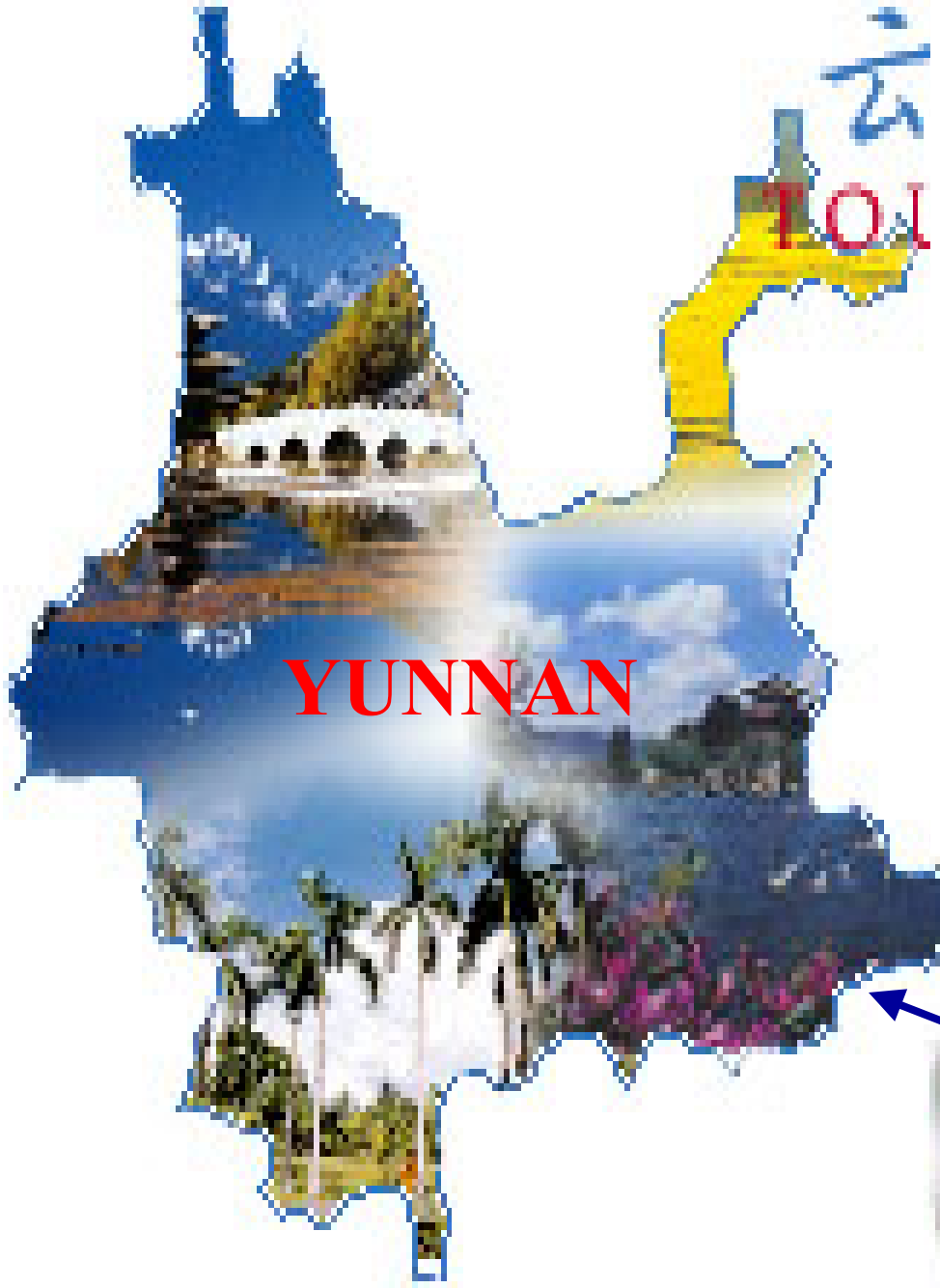
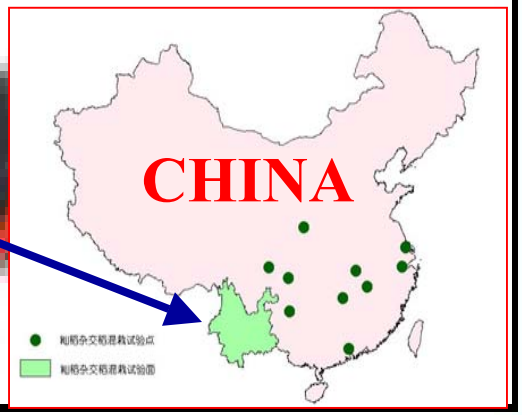




I came from Yunnan where is a very beautiful place

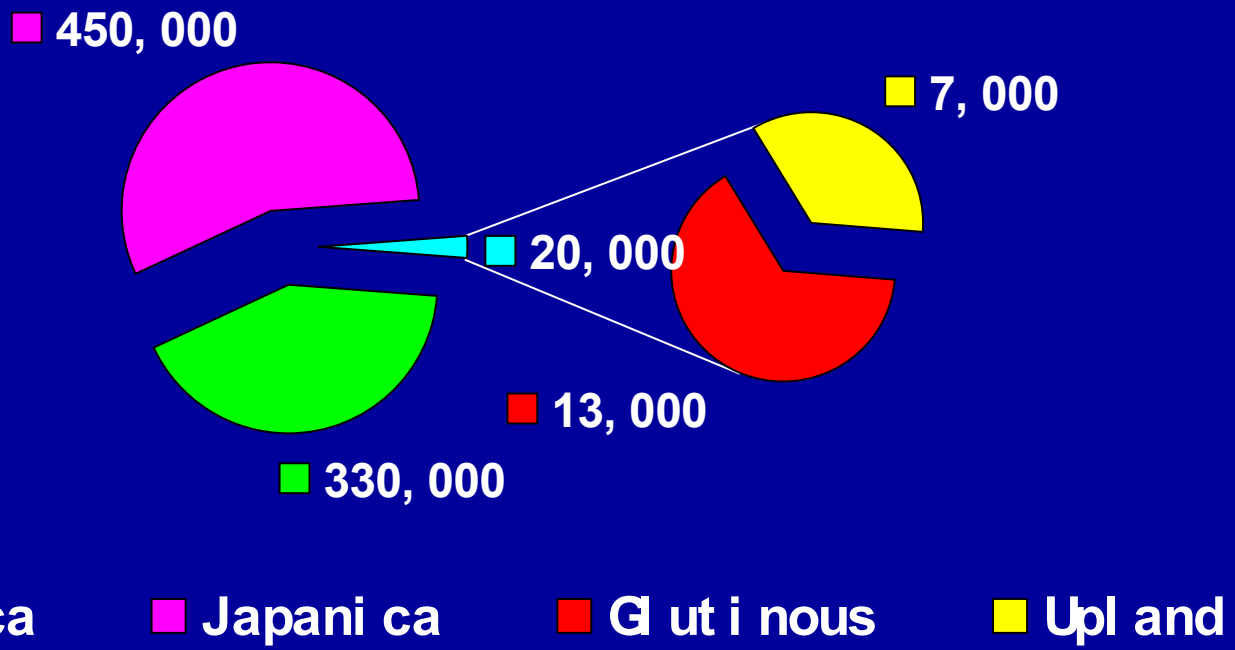


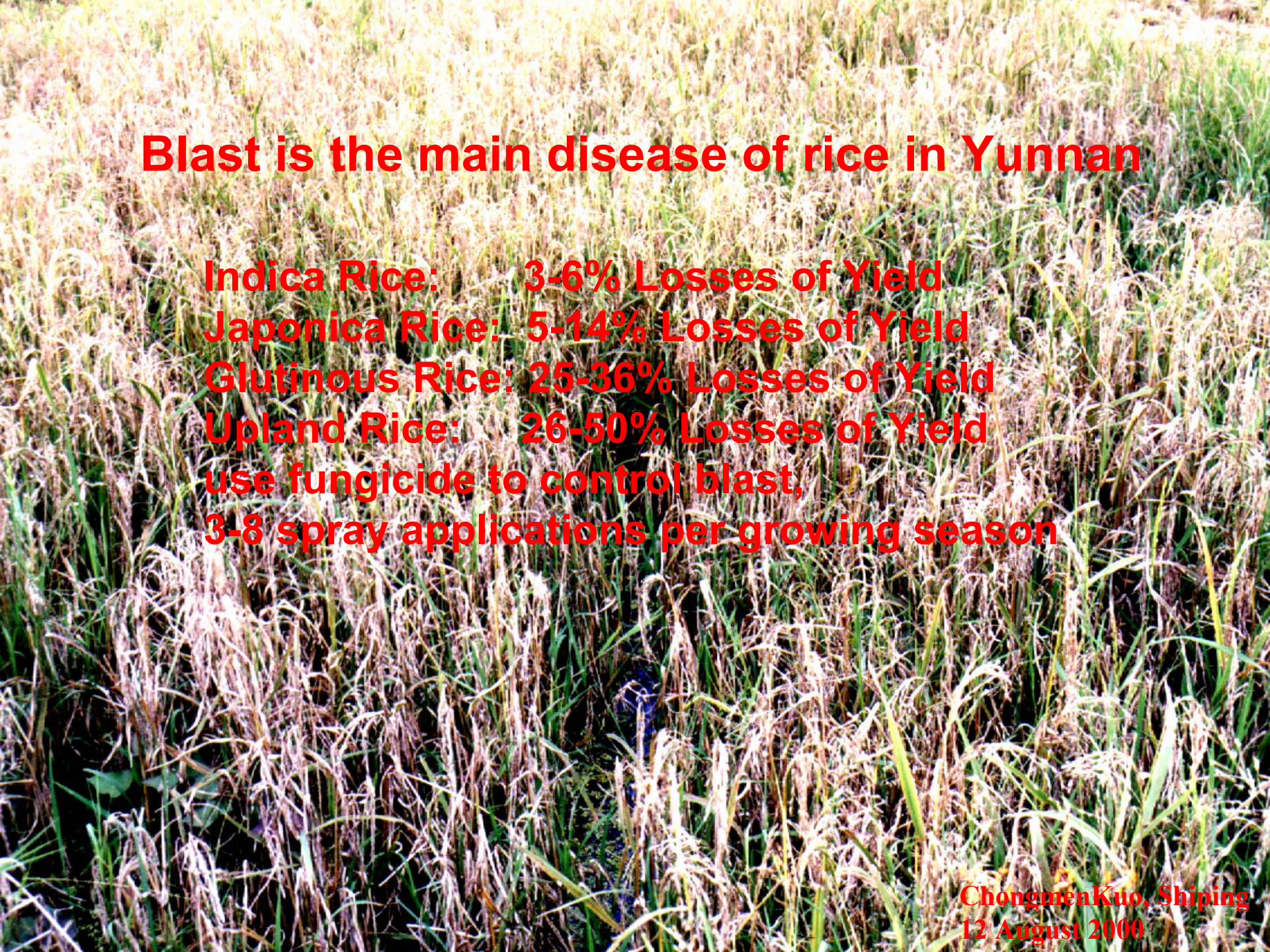
- Located in Southwest China
- From 20 to 29 degrees north latitude and from 97 to 196 degrees east longitude
- About 383 thousand square kilometers.
- The elevation to rice planting is highest at 2700 m at Lin Lang County, and lowest at 76 m at Hekou County.



Rice is major food crop in Yunnan

Total Rice Area in Yunnan: 800,000 ha




Blast is the main disease of rice in Yunnan
Indica Rice: 3-6% Losses of Yield
Japonica Rice: 5-14% Losses of Yield
Glutinous Rice: 25-36% Losses of Yield
Upland Rice: 26-50% Losses of Yield
use fungicide to control blast,
3-8 spray applications per growing season
ChongmenKuo, Shiping
12 August 2000

Hypothesis of genetic diversity for rice blast management

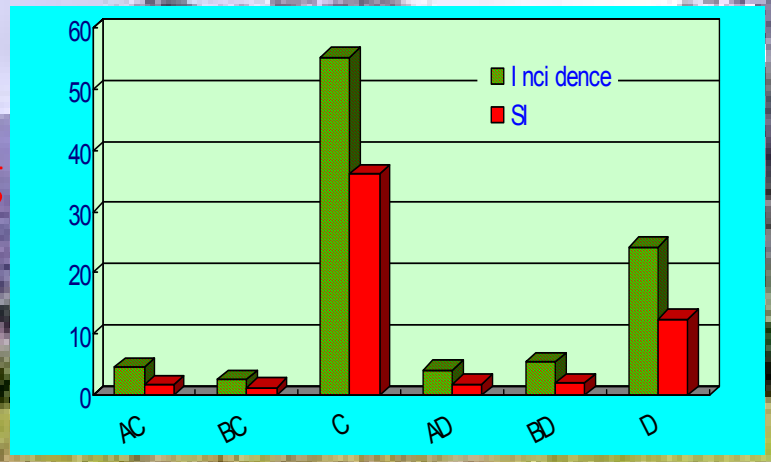
Different rice varieties are planted in a field or an area depending on the rice resources and sustainable agriculture development, for raising the ecology stability in field and strengthen deference of plant, to control rice blast.

Zhu youyong at el 1997

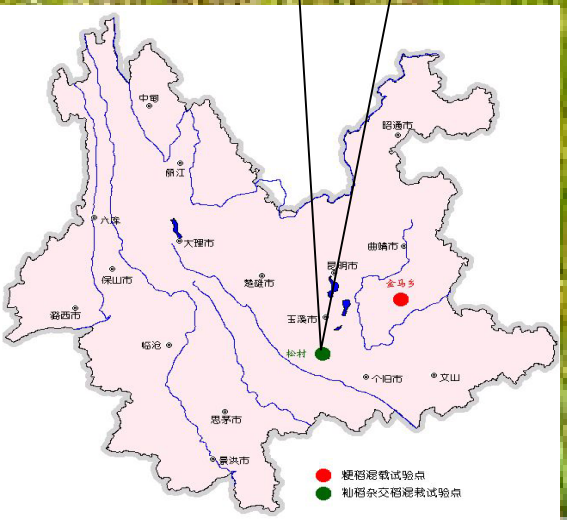
Method：One row of glutinous rice was added in hybrid rice between 4-6 rows

Mixture technique was accepted easily by more and more farmers

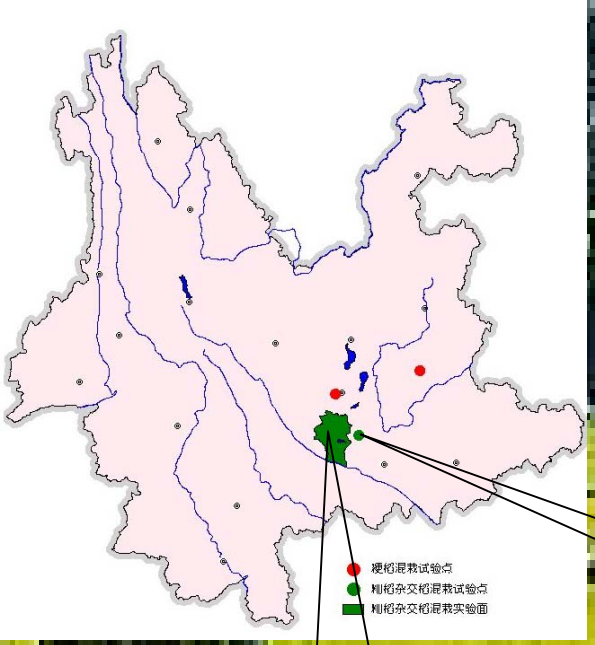
In 1997, The field experiments of variety diversity were done in 12 ha area of Shiping county of Yunnan.



Field experiment



Large Scale Field Trials In 1998

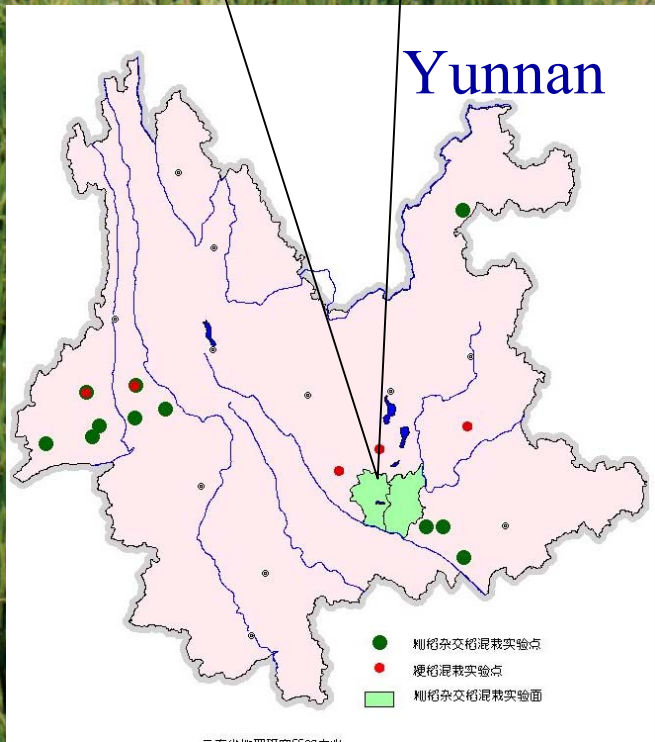


15 ha for mixture planting experiment in Jiangshui

812 ha for mixture planting in 5 towns of Shiping

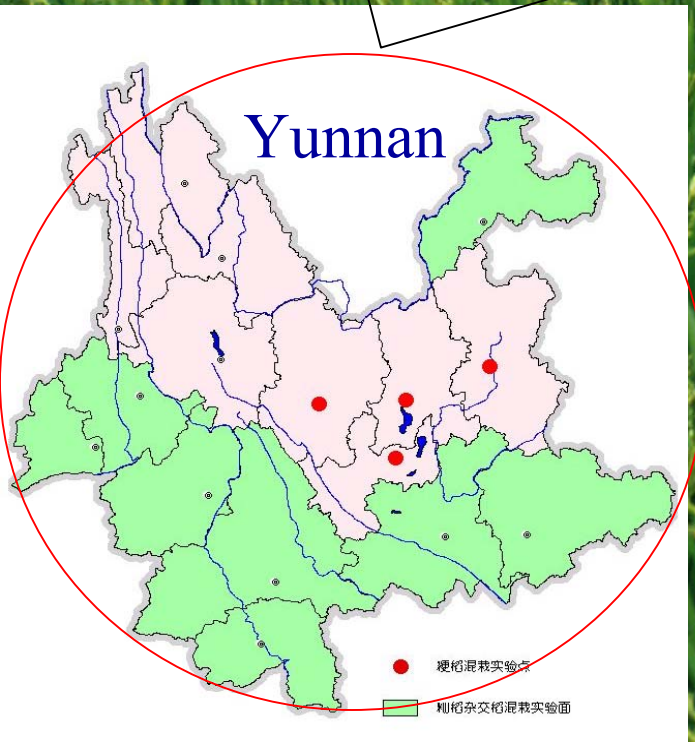
Large Scale Field Trials In 1999

3342 ha in Shiping and Jianshui counties



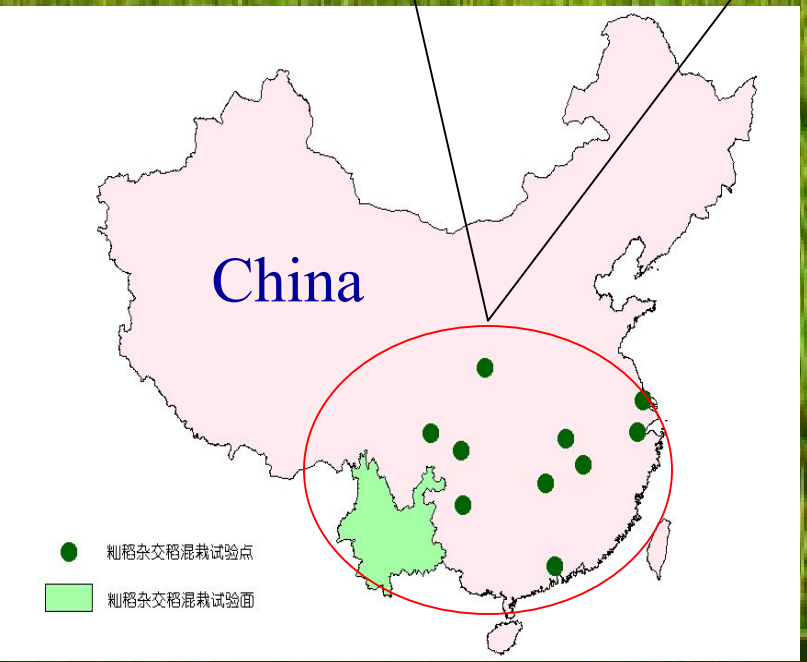
Large Scale Field Trials In 2000

43,000 ha for mixture planting in 41 counties of Yunnan in 2000



Large Scale Field Trials In 2001

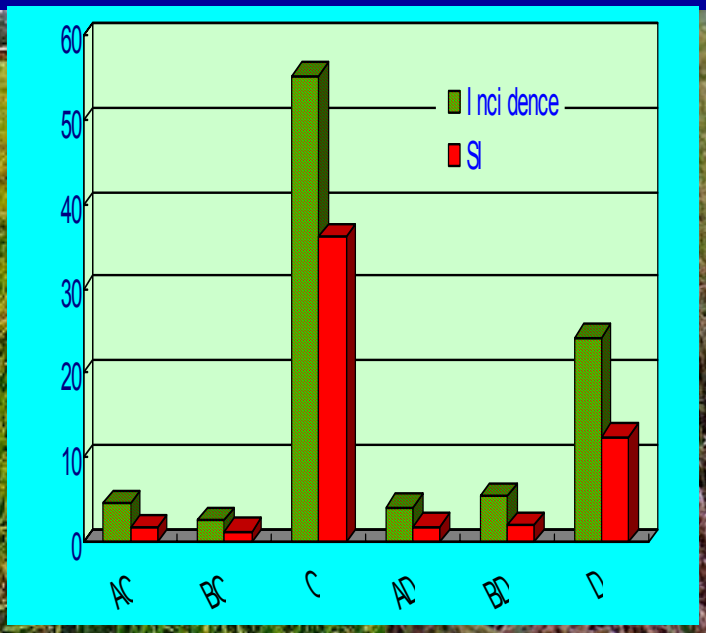
107,400 ha for mixture planting in 62 counties of China 2001



458 field experiments have been done in 48 counties of 11 provinces of China from 1997 to 2001

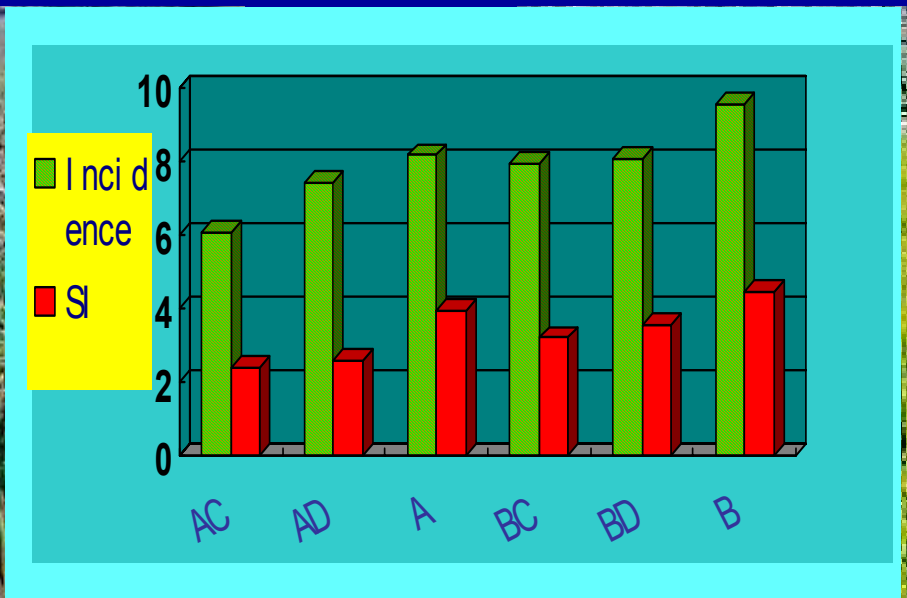
The results of variety diversity for rice blast management from field experiments

Rice blast of **disease-susceptible rice varieties** planted in mixtures with resistant varieties was 83-94% less severe than when they were grown in monoculture. Our results support the view that the variety diversification provides an ecological approach to disease control and contribute to the sustainability of crop production



The results of variety diversity for rice blast management from field experiments

Rice blast of **hybrid rice varieties** planted in mixtures with traditional varieties was 26-50.2% less severe than when they were grown in monoculture.

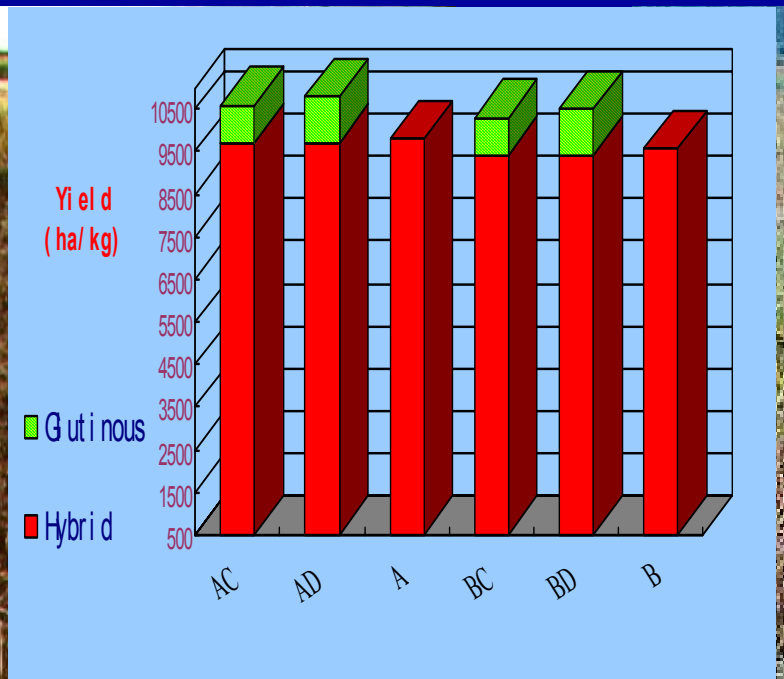


The results of variety diversity for the resistance of high quality variety to lodging

High quality varieties planted in mixtures with hybrid varieties had a strong resistance to lodging, and was 100% not to lodging than when they were grown in monoculture.

The results of variety diversity for rice yield increase from field experiments

Rice yield increased 636.3 to 1119.3 kg/ha. , especially disease-susceptible rice varieties planted in mixtures with resistant varieties had 89% greater yield than when they were grown in monoculture. .



The results of variety diversity for cost saving from reduction in pest pressure

Cost savings from reduction in pest pressure, Yunnan Province, China, 2000.

Item	Adopters	Nonadopters
Number of sprays	1	3
Cost of pesticides ($ ha^{-1})	10.5	42.92
Labor for pesticide application (d ha^{-1})	2.85	20.25
Imputed cost of labor ($ ha^{-1})	6.49	46.10
Total cost ($ ha^{-1})	16.99	89.02
Financial benefit ($ ha^{-1})	72.03	

Mechanization research

1.Rice variety

Analysis on Resistance Gene Analogue (RGA) of rice variety

Analysis on RFLP of Candidate resistance gene of rice variety

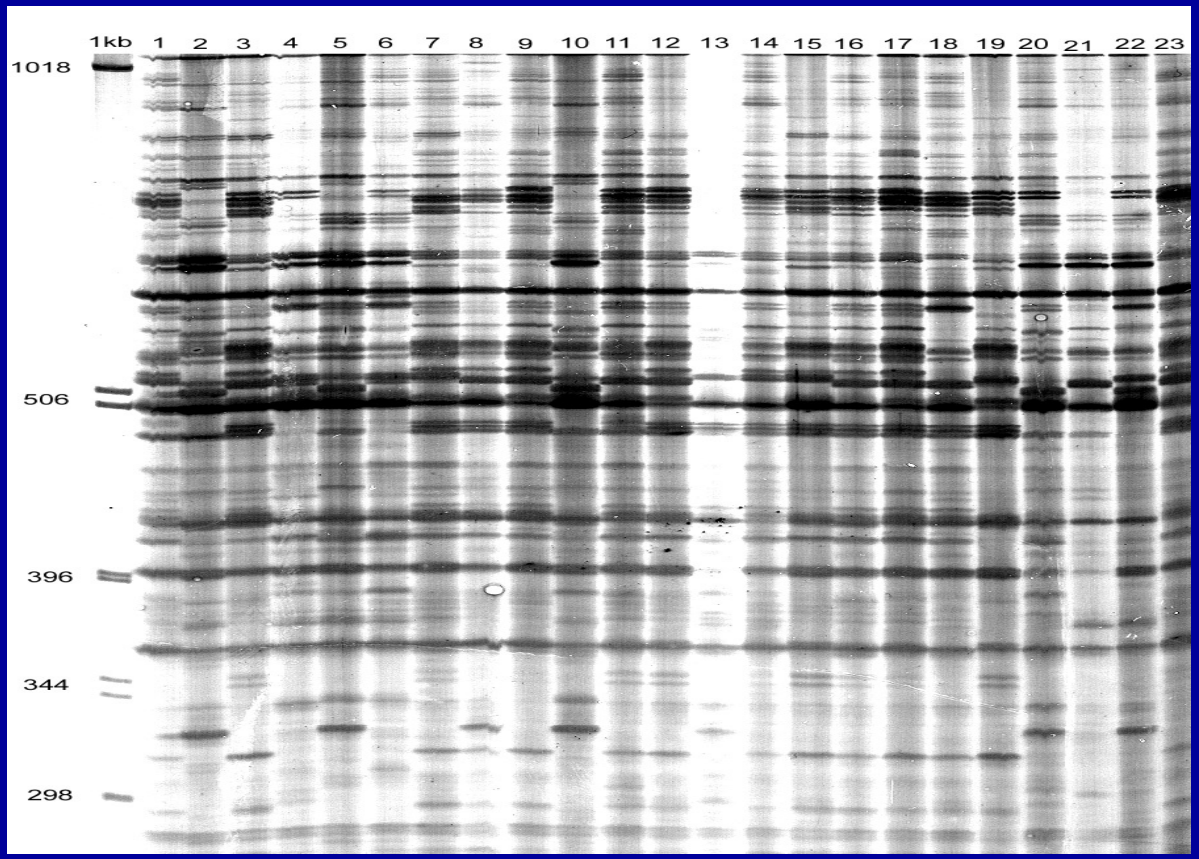
2.Blast pathogen

Population structure and Genetic Diversity of *Magnaporthe grisea* analysis by rep-PCR fingerprint

3.Relationship between rice variety and blast pathogen

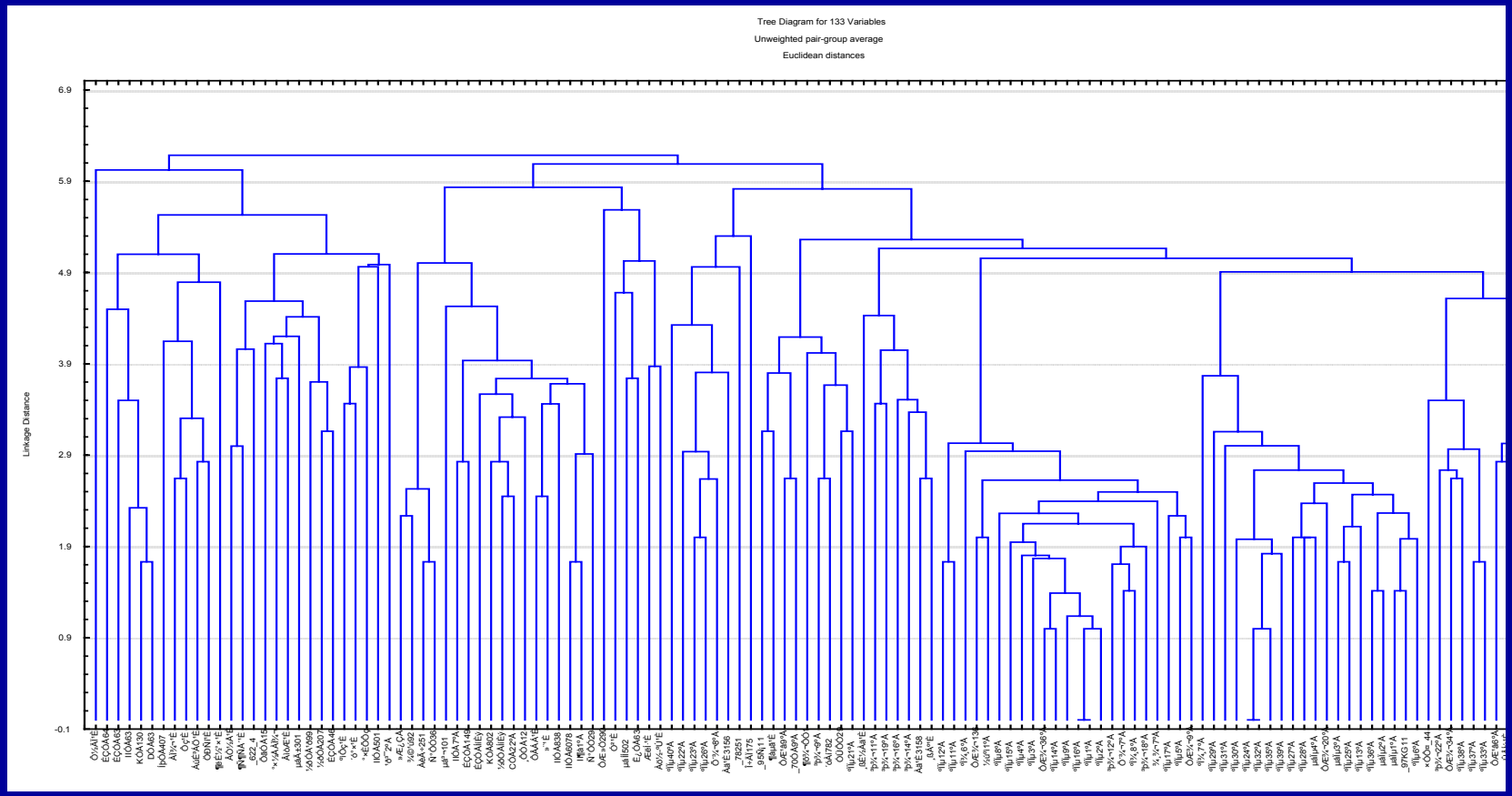
4.Microclimate in field 直截40□

Polymorphsium of fingerprint patterns for rice varieties from Yunnan by RGA-PCR

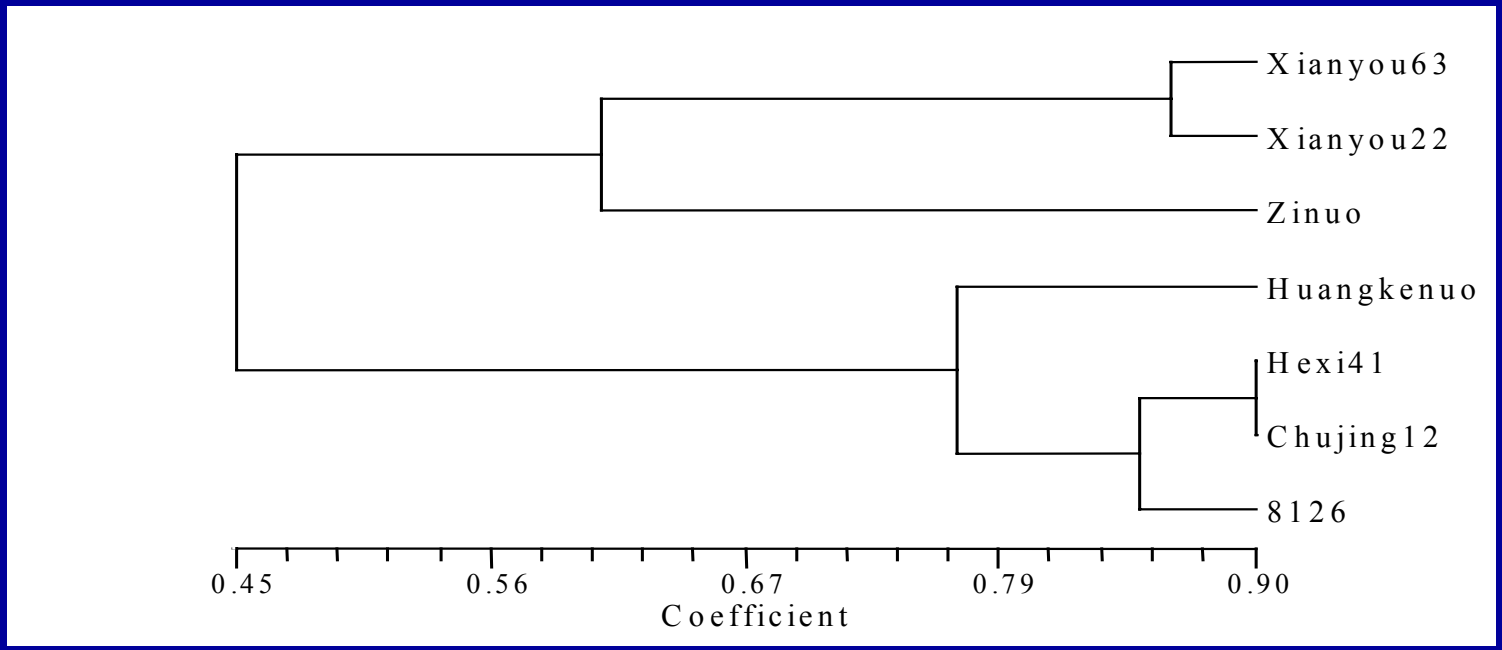


215 varieties from all rice growing area in Yunnan were assessed for LRR space polymorphism using AFLP with 3 pairs primers: Pto-kin1/Pto-kin2, S1/ AS3, XLRR for/ XLRR rev

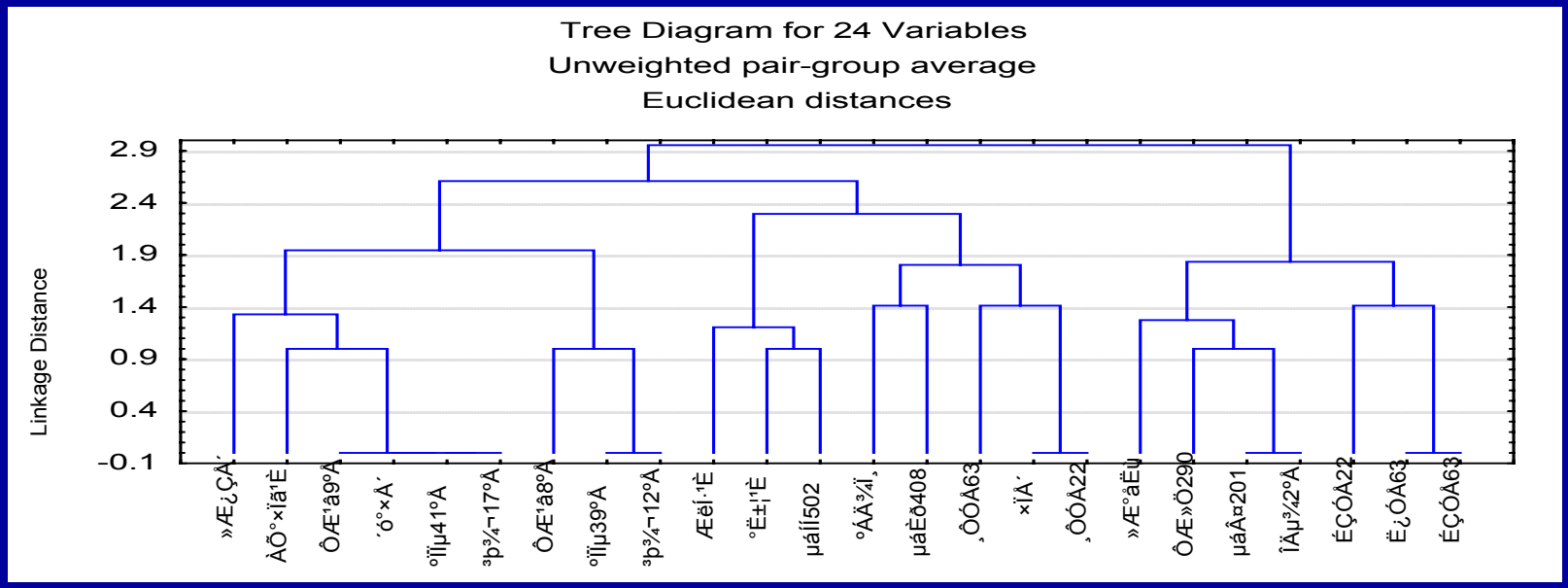
Computer clusters results of 215 varieties for amplification with 3 pairs: XLRR for/ XLRR rev、S1/ AS3、Pto-kin1 /Pto-kin2

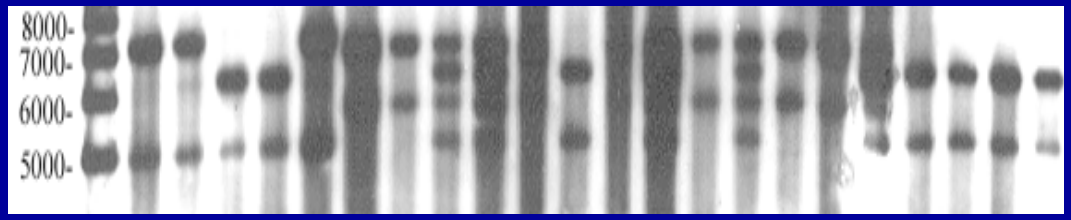


Zhu Youyong & Hei Lueng (2000)



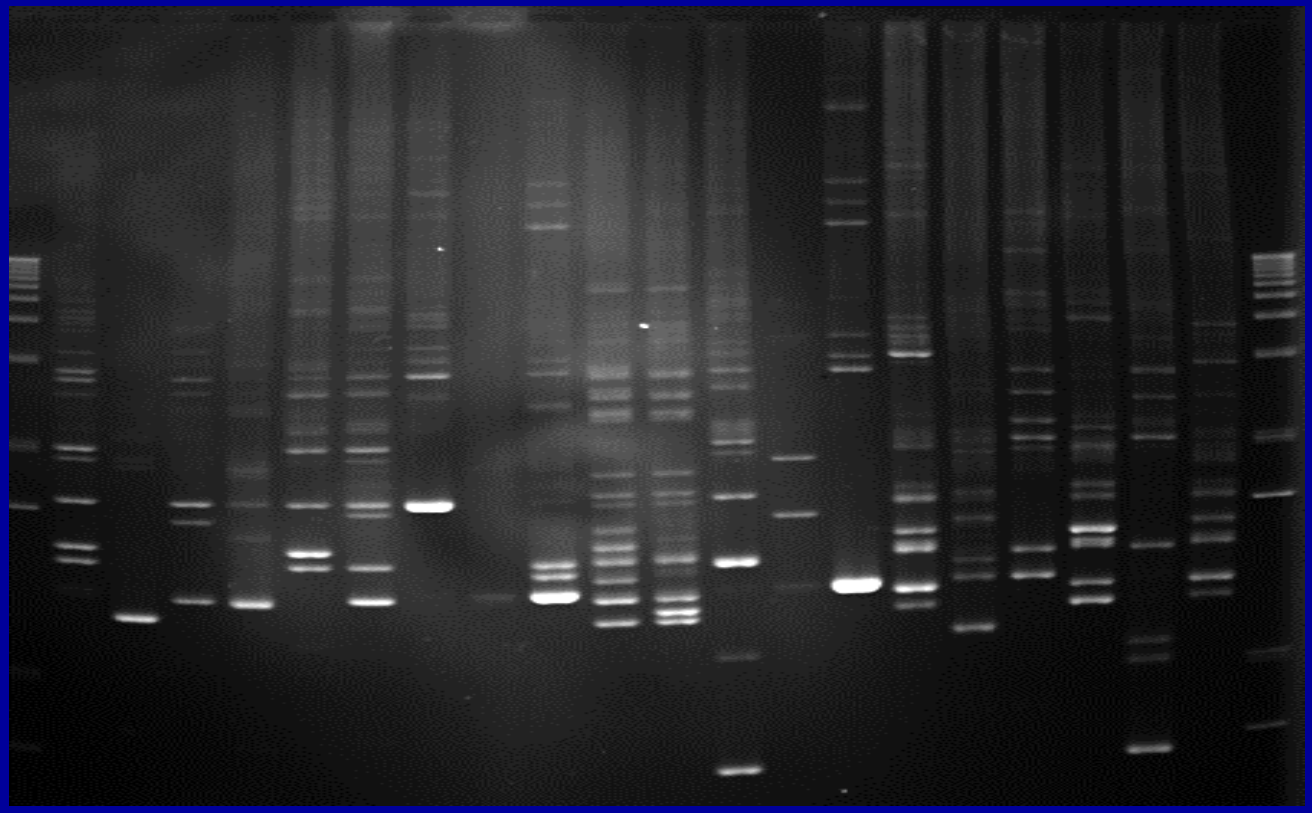
Rice varieties assessed by RFLP with 19 candidate R.gene probes





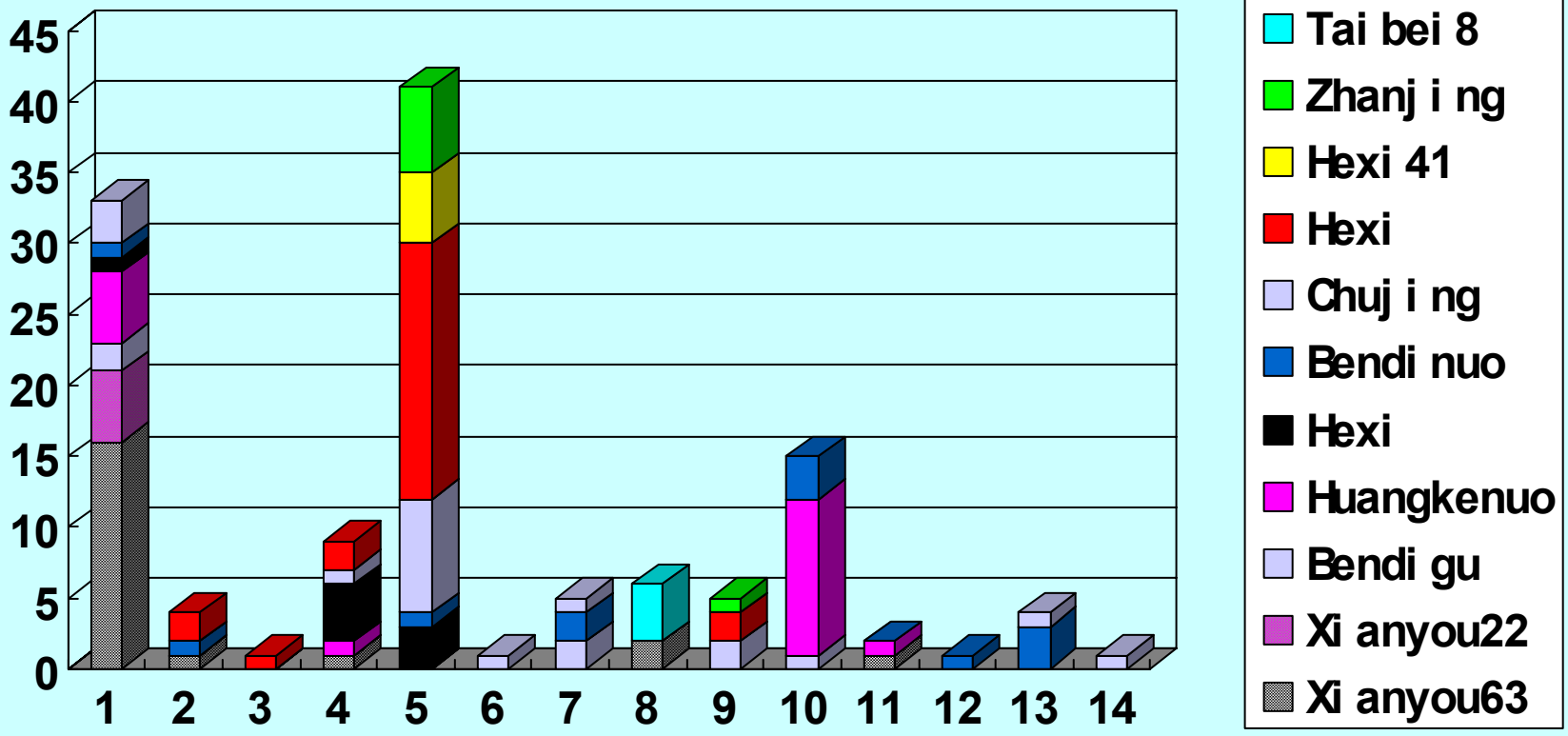
Wang Yunyue, He Yueqiu & Sun Yin (2000)

Population structure of *Magnaporthe grisea* analysis by rep-PCR fingerprint

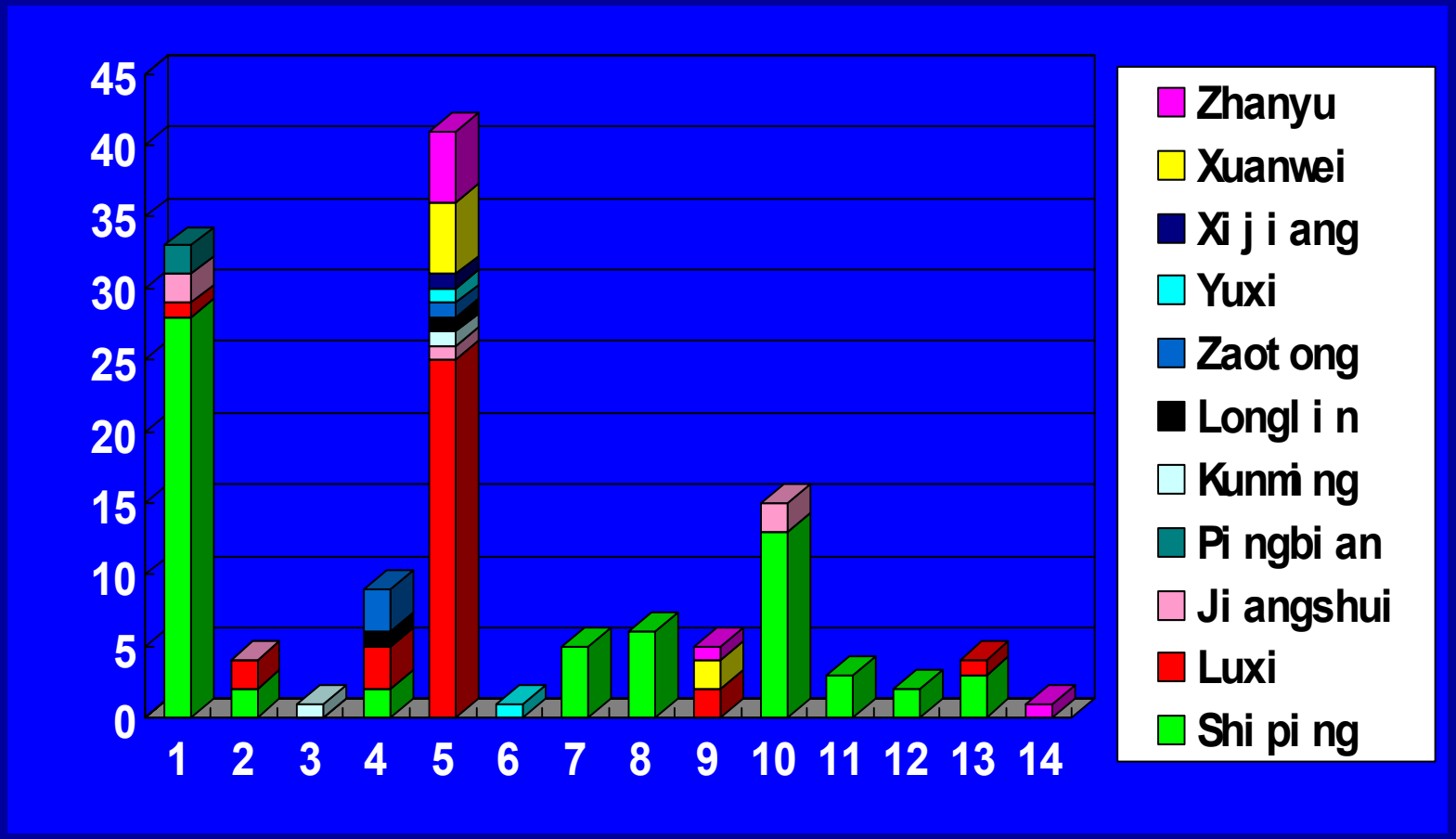


2314 isolates of Magnaporthe grisea from Yunnan and other 9 provinces were assessed by rep-PCR with the primer Pot2.

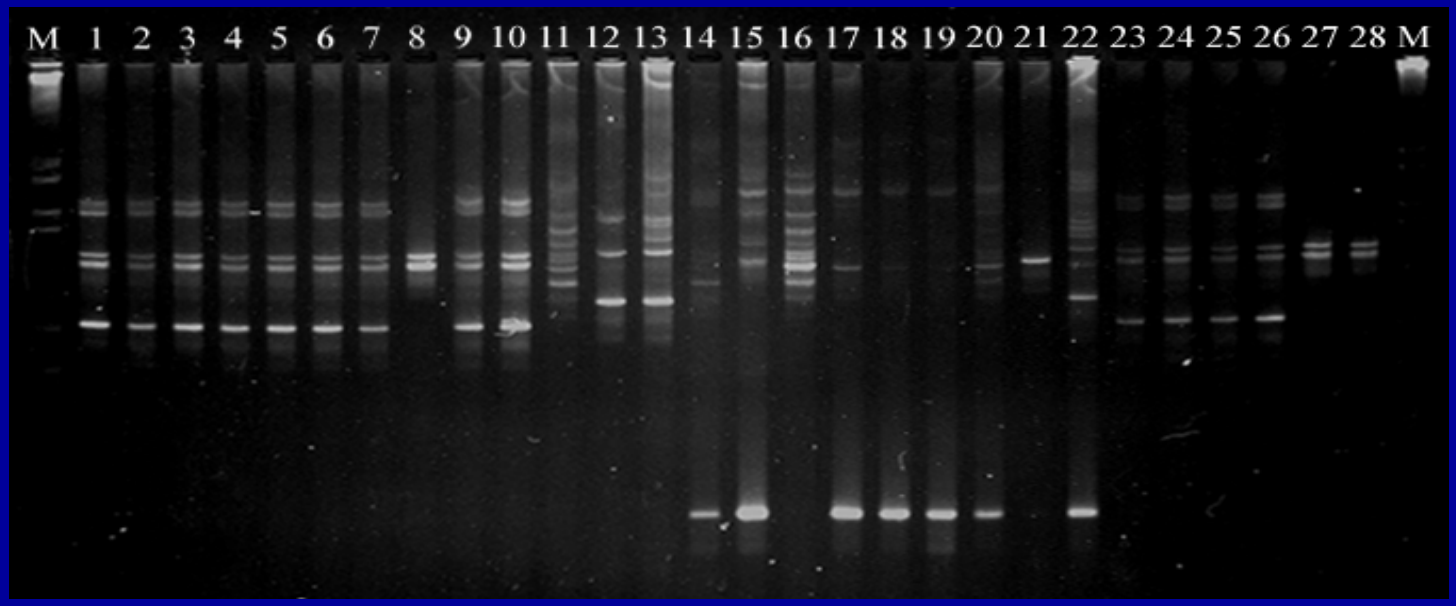
Relationship between Rep-PCR groups of isolates and rice varieties



Relationship between Rep-PCR groups and the region of isolates

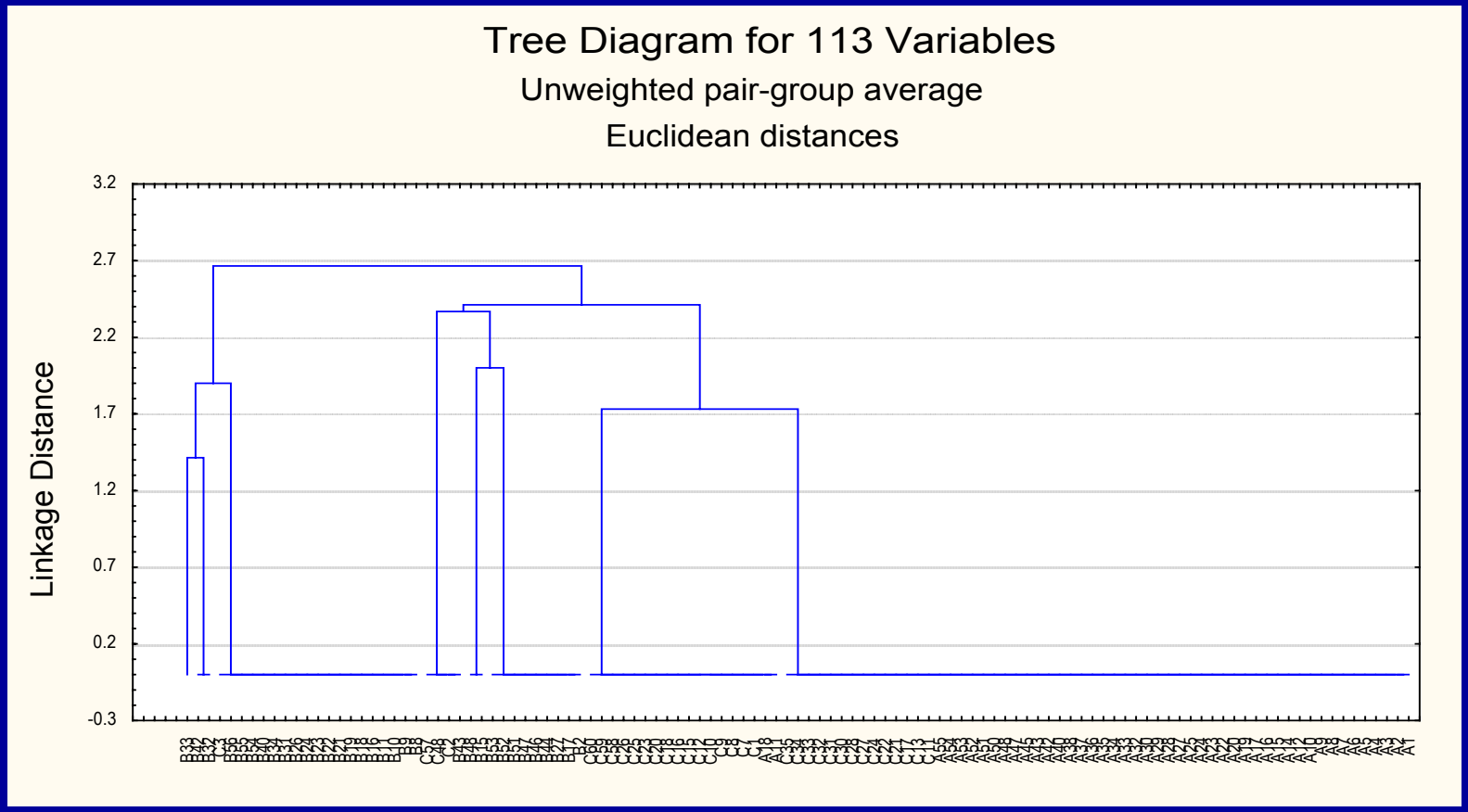


Blast isolates were diversified by rice variety diversity

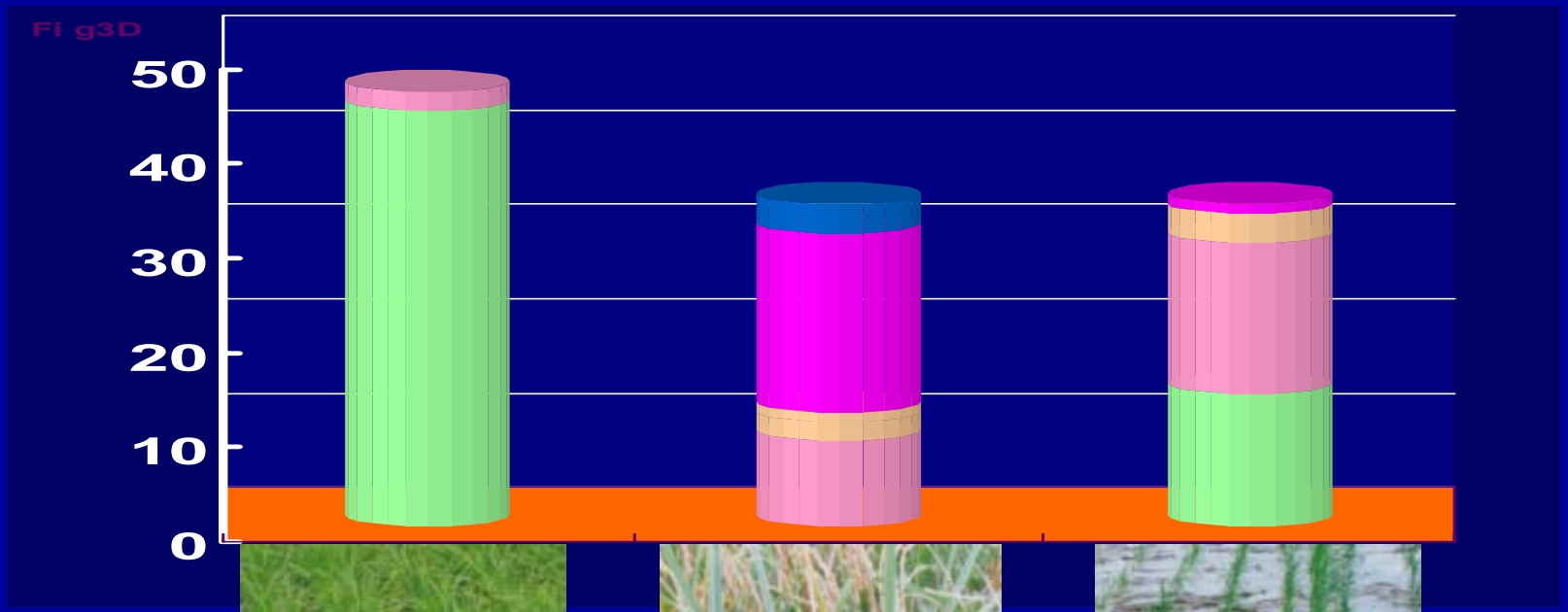


1 and 30 lanes: markers (λDNA with hindIII and EcoRI); 2 to 11 lanes: Isolates from monoplanting of Indica rice (Shanyou63); 12 to 21 lanes: Isolates from monoplanting gultinous rice(Huangkenuo); 22 to 29 lanes: Isolates from Mixture inter-planting (Shanyou63 and Huangkenuo)

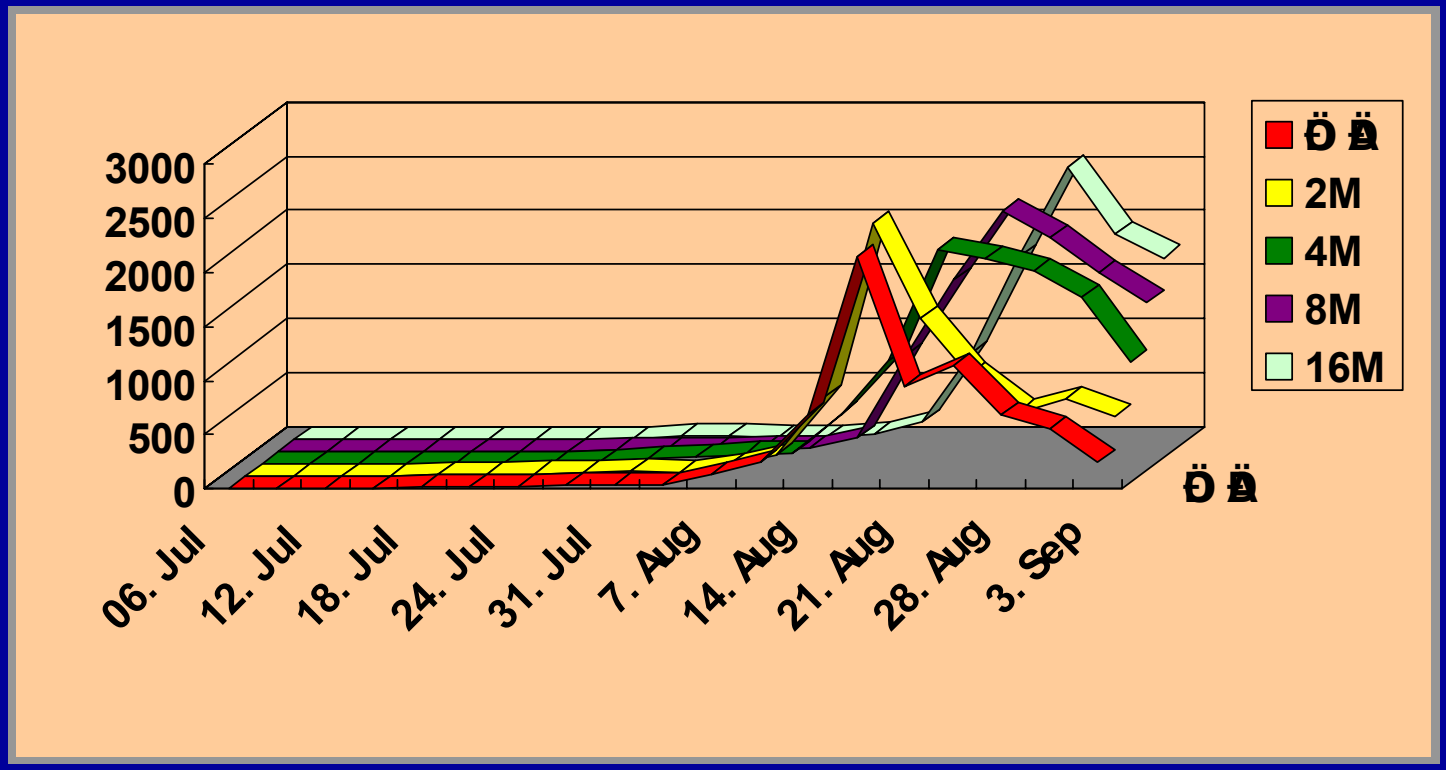
The cluster results 113 isolates from monoculture and mixture inter-planting fields



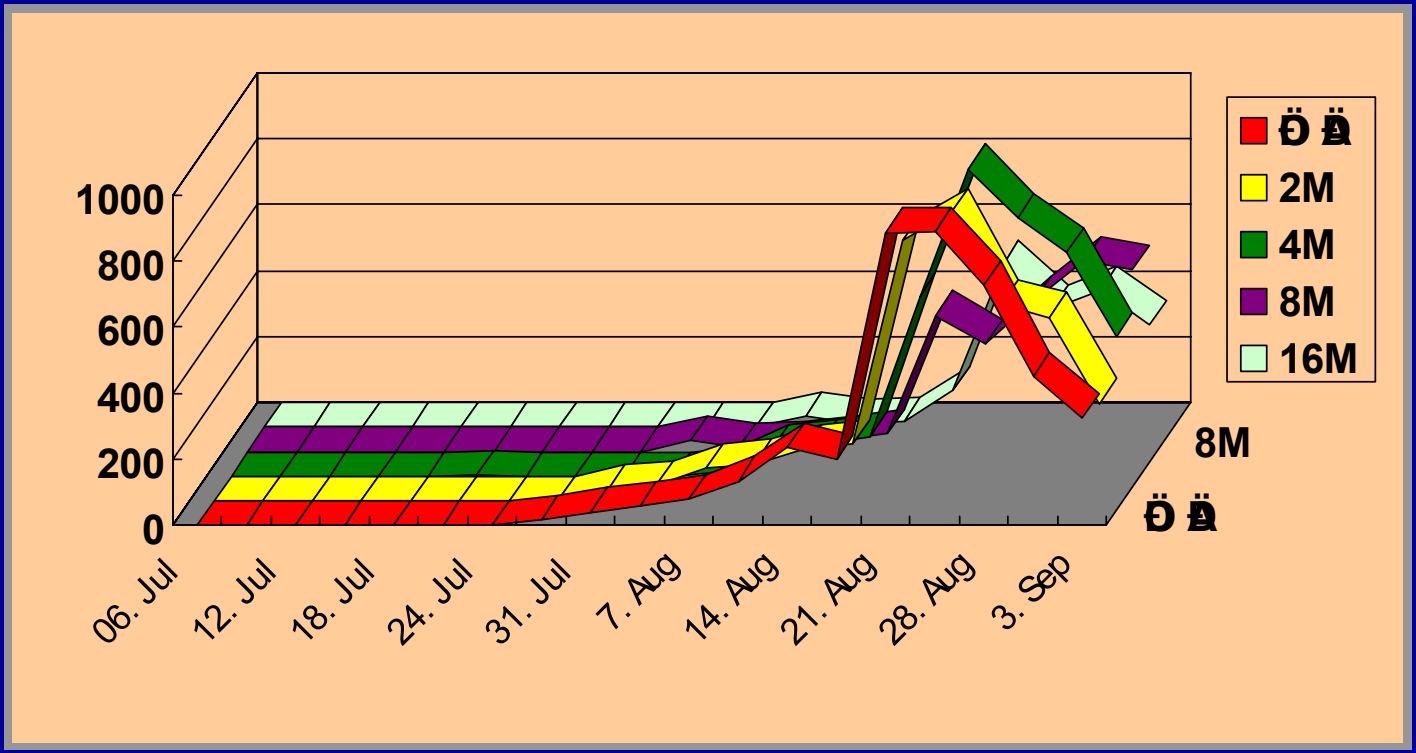
The cluster results 113 isolates from monoculture and mixture inter-planting fields



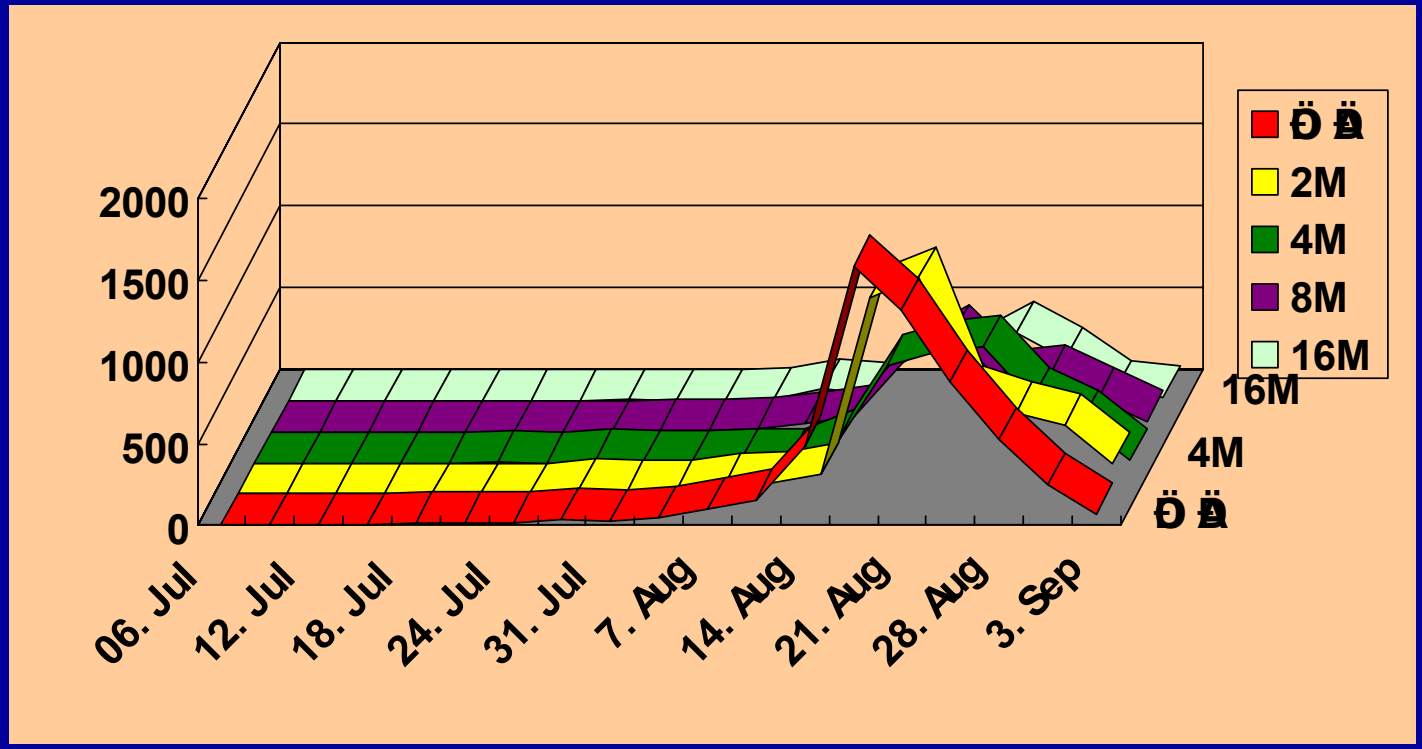
Spore proliferation of blast pathogen in monoculture susceptible variety (Huangkenuo) field



Spore proliferation of blast pathogen in monoculture resistance variety (Shanyou63) field

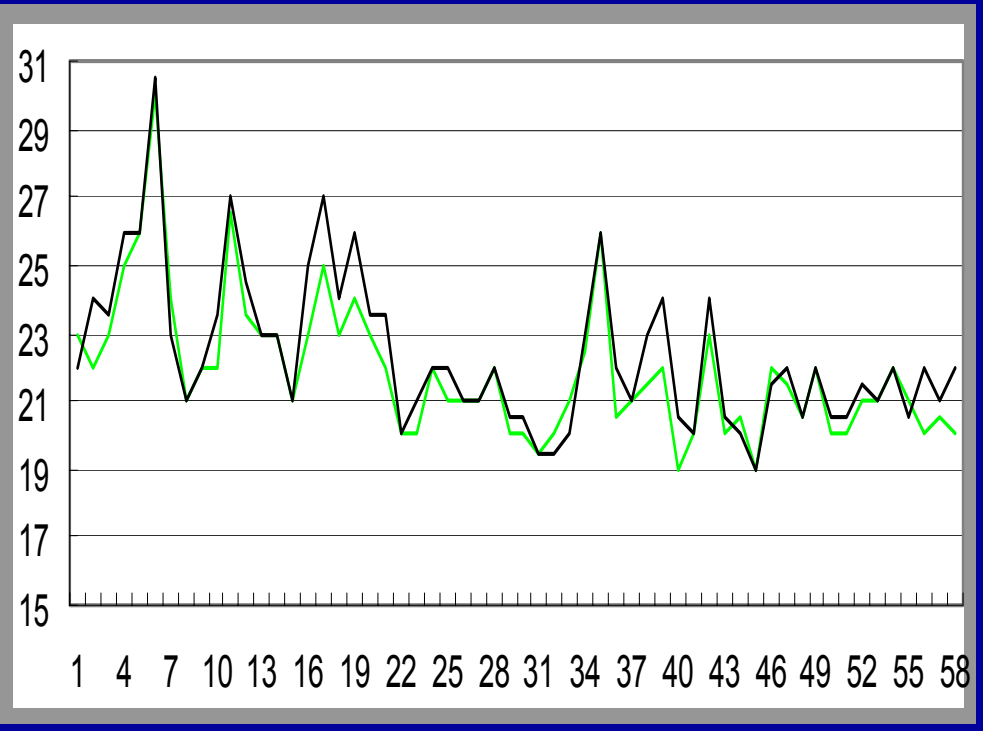


Spore proliferation of blast pathogen in mixture inter-planting field (Shanyou63/huangkenuo)

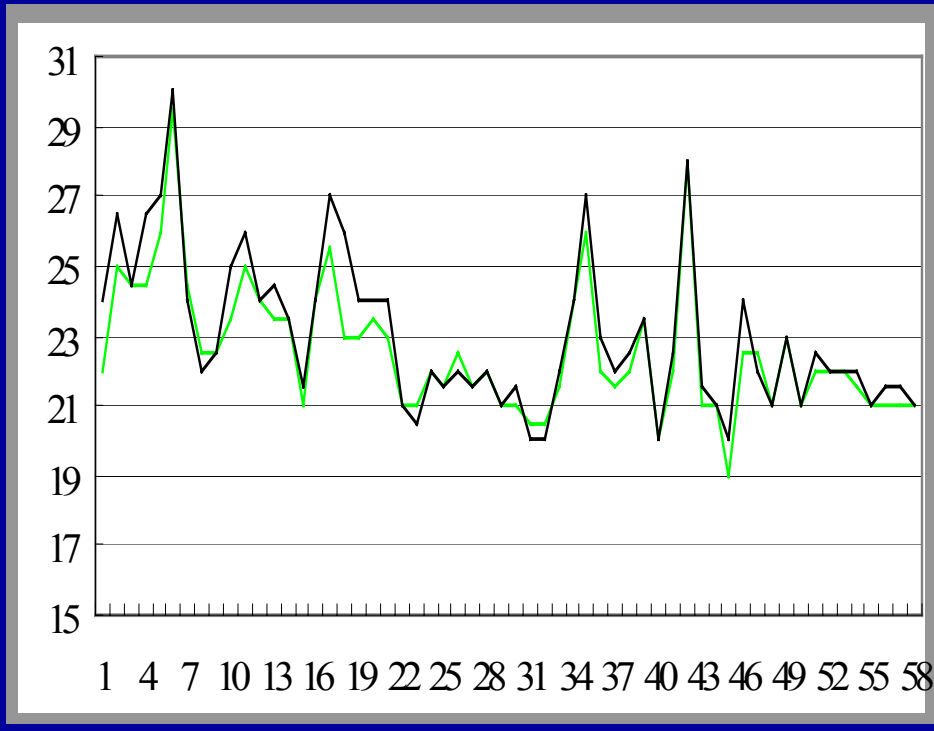


Microclimate in monoculture and mixture-culture fields

(The temperature change curves at 8:00)

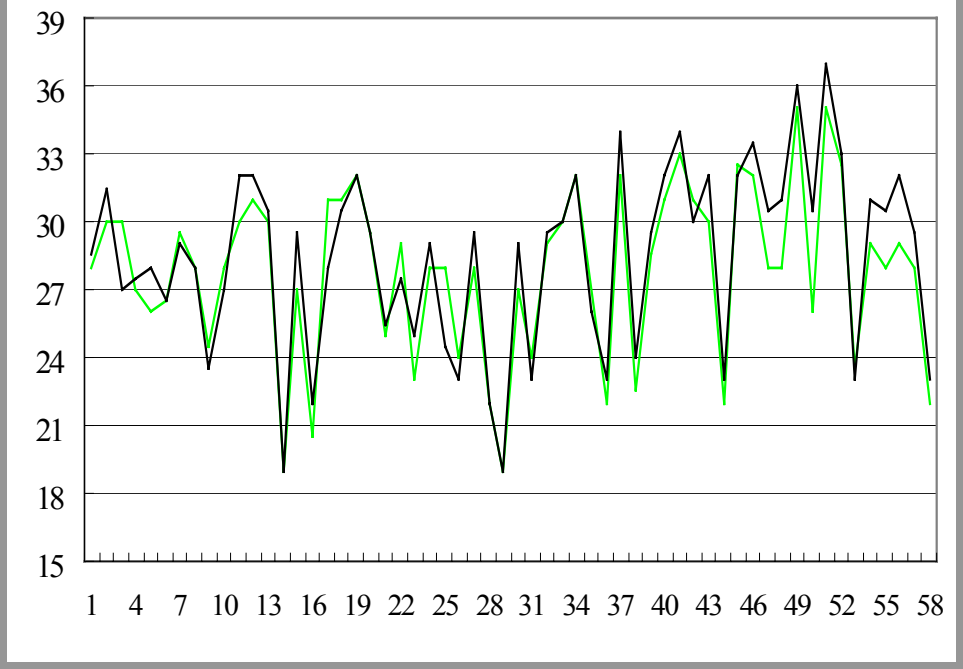


— A/D
— D

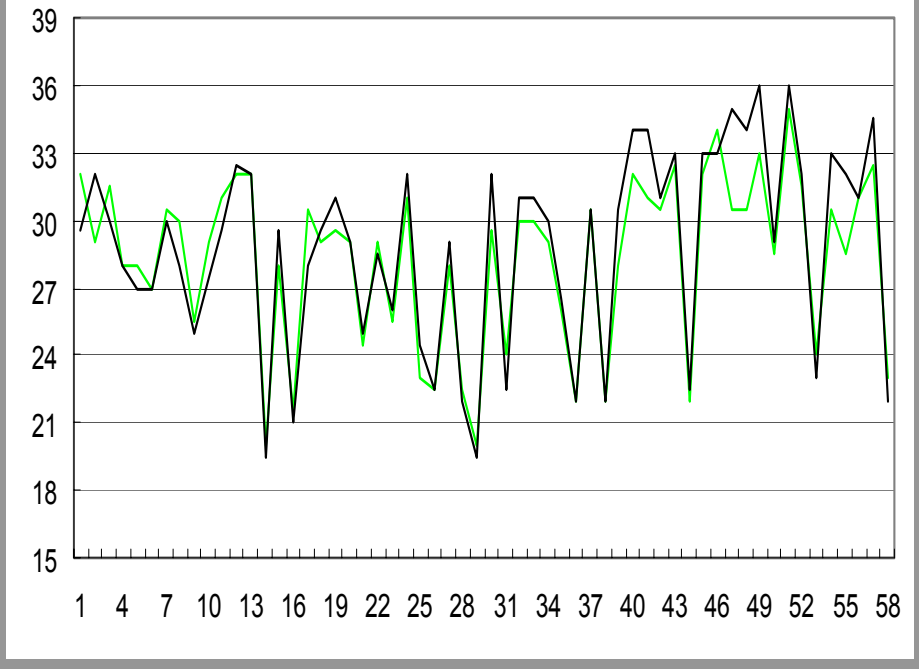


— B/C
— C

(The temperature change curves at 14:00)

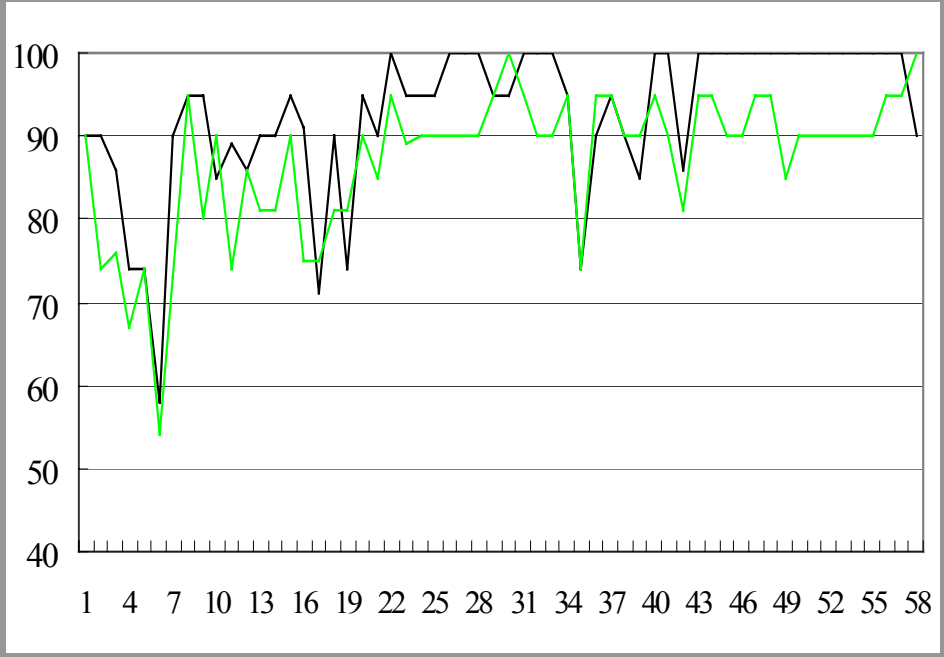


A/D
D

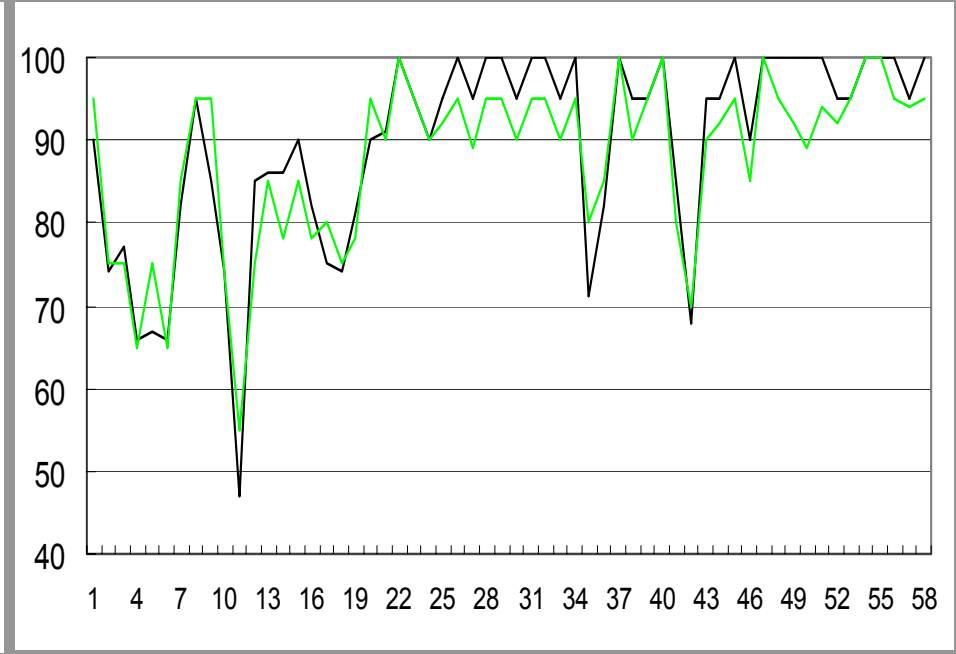


B/C
C

(The relation humidity change curves at 8:00)

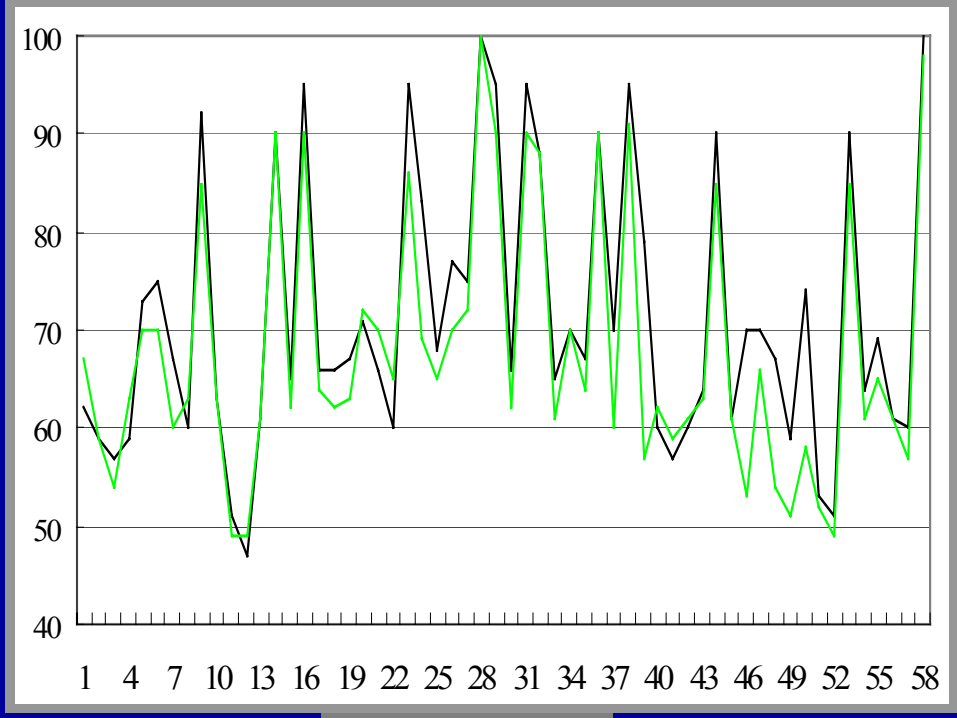


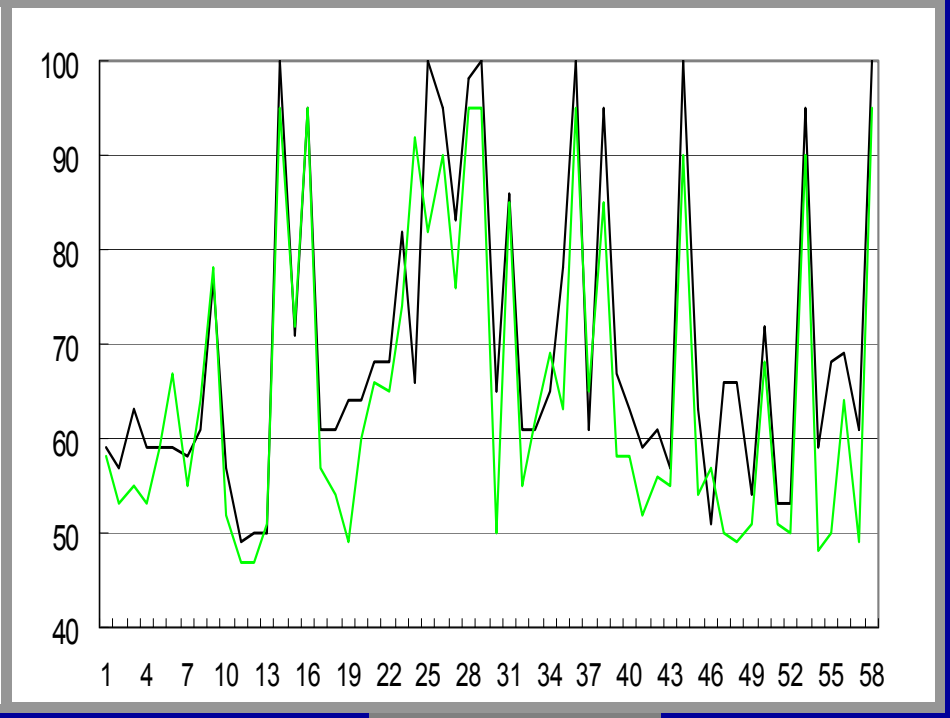
D
A/D



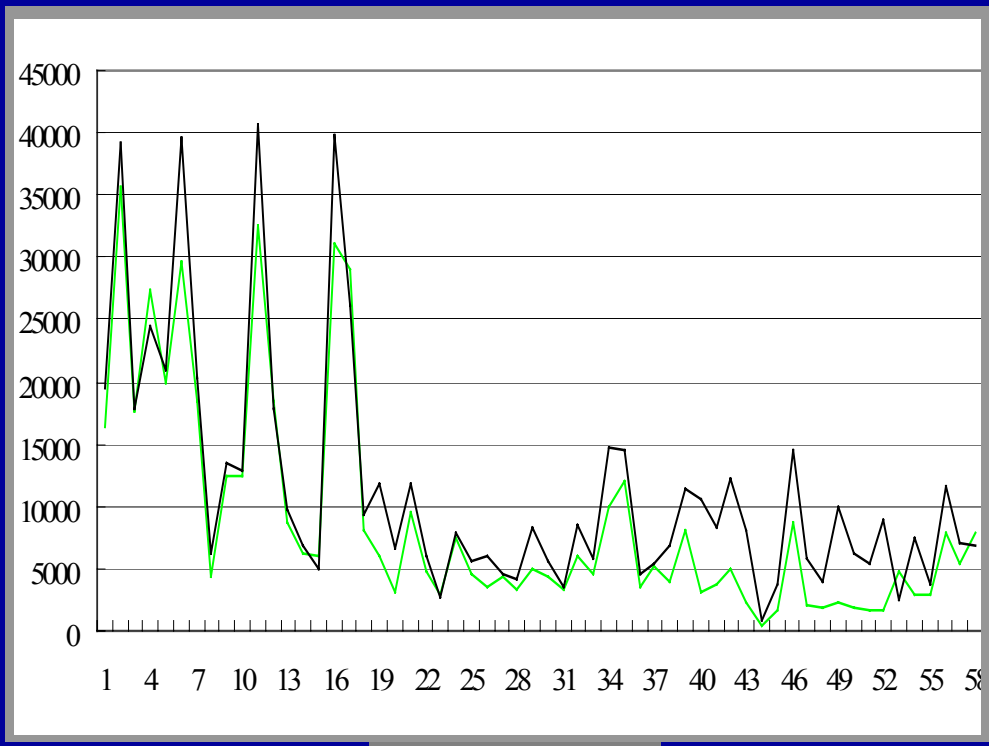
C
B/C

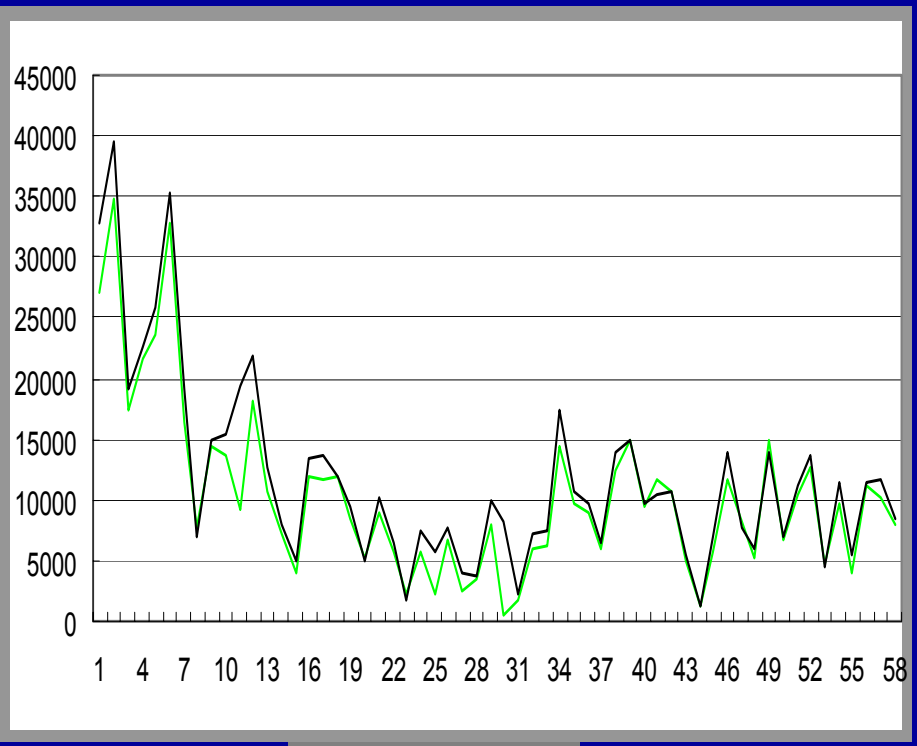
The relative humidity change curves at 14:00



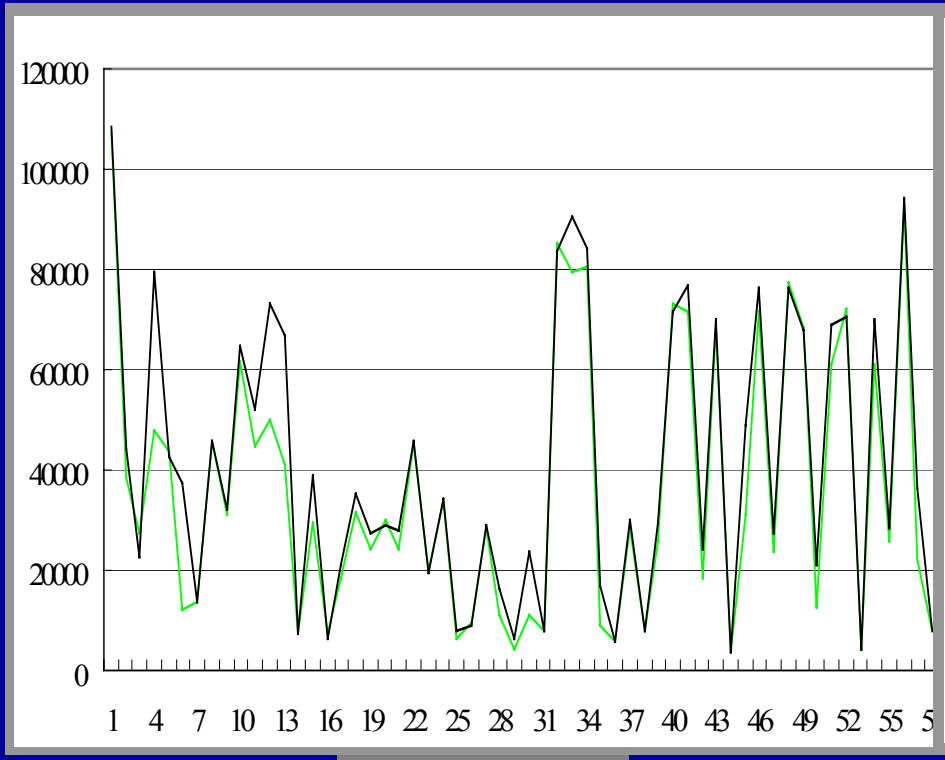


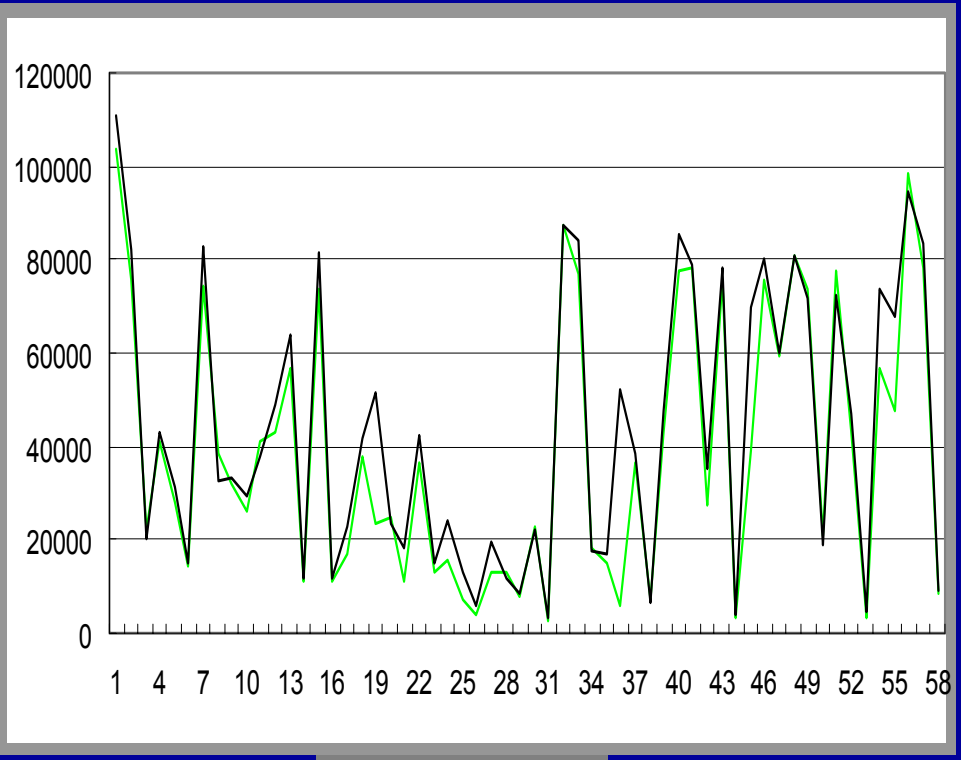
(The illumination change curves at 8:00)





The illumination change curves at 14:00





Nature

Vol.406, No.6797, pp:718 - 722

Genetic diversity and disease control in rice

YOUYONG ZHU, HAIRU CHEN, JINGHUA FAN, YUNYUE WANG, YAN LI, JIANBING CHEN, JINXIANG FAN, SHISHENG YANG, LINGPING HU, HEI LEUNG, TOM W. MEW, PAUL S. TENG, ZONGHUA WANG & CHRISTOPHER C. MUNDT

Crop heterogeneity is a possible solution to the vulnerability of monocultured crops to disease. Both theory and observation indicate that genetic heterogeneity provides greater disease suppression when used over large areas, though experimental data are lacking. Here we report a unique cooperation among farmers, researchers and extension personnel in Yunnan Province, China—genetically diversified rice crops were planted in all the rice fields in five townships in 1998 and ten townships in 1999. Control plots of monocultured crops allowed us to calculate the effect of diversity on the severity of rice blast, the major disease of rice. Disease-susceptible rice varieties planted in mixtures with resistant varieties had 89% greater yield and blast was 94% less severe than when they were grown in monoculture. The experiment was so successful that fungicidal sprays were no longer applied by the end of the two-year programme. Our results support the view that intraspecific crop diversification provides an ecological approach to disease control that can be highly effective over a large area and contribute to the sustainability of crop production

Highly appraise in Nature, Science and other newspaper

news and views

Crop strength through diversity

Martin S. Wolfe

In conventional farming, single varieties of crop plants are grown alone. But mixing varieties may be a better option: several rice strains, planted together on a large scale, are more resistant to a major fungal disease.

Attempted solutions to the problems caused by modern agriculture, such as the overuse of fertilizers and pesticides, are usually expensive and often lead to new problems. But this need not be so, as Zhu and colleagues show on page 718 of this issue[1]. By

Figure 1 **The main disease of rice (rice blast, pictured inset) spreads more slowly in mixtures of rice varieties than in monocultures, as Zhu *et al.*[1] discover in their large-scale experiments in China.**

HOLT STUDIOS

NEWS OF THE WEEK

…oastwide management plan was needed, so …ey asked the Atlantic States Marine Fish…ries Commission (ASMFC) to design one.

The scientists charged with the task soon …ealized that there was a lack of good data …n horseshoe crab populations, says Jim …erkson, a fisheries scientist at Virginia …olytechnic Institute and State University in …lacksburg who participated in the stock as…essment committee. But they were alarmed …y the still-increasing harvest, fearing long-…asting effects on a species that takes 9 to 11 …ears to reach sexual maturity.

In February, ASMFC voted for a 25% re…duction of the average harvest levels from …995 through 1997. This was a compromise …etween the 50% cut desired by Maryland …nd other states and the status quo sought by …irginia. Virginia officials objected to what …hey said amounted to a 75% cut in what the …tate's conch industry needed. They argued …hat state laws require them to base their de…isions on good science—which, they said, …as absent here. State officials also argued …hat the problem needed to be quantified be…fore a quota was established.

That position didn't pass muster with the …ommission, which saw it as a delaying tac…tic. In May, it found Virginia "out of compli…ance" and asked the Department of Com…merce to shut down Virginia fisheries for not …dhering to the commission's quota. "The …ottom line is that decisions are made with …hatever information is available," says …ieter Busch, director of ASMFC's Interstate …isheries Management Program. Virginia's …arine Resources Commission has since re…duced the legal harvest in half, to 355,000 …rabs. But that still isn't good enough for …ederal officials. Last week the Department …f Commerce proposed a moratorium for …eptember, the start of the fall harvest.

Virginia hopes to convince the Atlantic …ommission at a meeting next week to ease …ts quota, and the fishing industry is watching …losely. "We're hopeful," says Rick Robins, …ho runs Chesapeake Bay Packing in New…ort News, Virginia, the largest exporter of …onch. "But we're prepared to seek an injunc…tion," he says, if the commission stands firm.

—ERIK STOKSTAD

AGRICULTURE

Variety Spices Up Chinese Rice Yields

The results of Chinese field trials re…inforce the accepted scientific wisdom …hat planting different varieties of a crop …n the same field holds down the spread of …ertain diseases and improves yields. And …his time researchers seem to have con…vinced farmers, too.

Zhu Youyong, a plant pathologist at the Phytopathology Laboratory of Yun…nan Province af Yunnan Agricultur…al University in Kunming, China, and colleagues re…port in the 17 Au…gust issue of *Nature* on a 2-year experi…ment that involved mixing two varieties of rice in the same field. Their work, in…volving thousands of local rice farmers, found an 18% rise in overall productivity, including greater profits for a premium-priced va…riety that is particu…larly susceptible to rice blast from a fungus.

Mixing it up. Mono…cultural plantings of rice, common in Yun…nan Province and else…where, are more vul…nerable to disease.

Most Yunnan farmers plant one variety of hybrid rice, with a few devoting some land to a more glutinous rice used for desserts and other regional specialties. Following Zhu's suggestion, however, farmers planted a single row of glutinous rice in the middle of a group of either four or six rows of hybrid rice. The experiment started on 812 hectares in 1998 and expanded to 3342 hectares in 1999. Monoculture control plots were grown at 15 small sites throughout the region.

The results show the power of variety. Researchers calculated that it would take an average of 1.18 hectares of monoculture cropland to produce the same amounts of hybrid and glutinous rice produced in 1 hectare of mixed crops. The most striking change was for individual glutinous plants grown in a mixed environment: They yield…ed up to 89% more rice than their monocul…tural cousins. What's more, because the glutinous rice fetches a premium price, the value per hectare of the mixed fields was 14% greater than the hybrid monoculture plots and 40% greater than the glutinous monoculture plots. In both years, blast de…stroyed about 20% of the glutinous rice grain in the monoculture plots but only 1% in the mixed plots. Blast damage in the hy…brid rice, although much lower in general, also dropped, with a grain loss of only 1% in the mixed plots versus 2.3% in monoculture plots. The damage from blast was so re…duced in the mixed plots that farmers stopped their periodic fungicide spraying. "The farmers are very happy," says Zhu.

Christopher Mundt, a plant pathologist at Oregon State University in Corvallis and a co-author of the paper, explains that differ…ent types of rice blast attack different vari…eties of rice. In a monoculture field of rice, he says, the blast can spread "like a fire through a field of dry grass." The fungus has a harder time finding a compatible host in a mixed environment.

Martin Wolfe, a plant pathologist and re…search director of the Elm Farm Research Center, an organic farming research center in Hamstead Marshall, Newbury, U.K., sup…ports the approach but notes that the mixture must be tailored to local growing conditions. "This is a useful tool," says Wolfe, who has written a commentary in the same issue. "But you can't just rush in and plant togeth…er anything you like."

The message from Zhu's study appears to be spreading through Yunnan Province, where this year 40,000 hectares were planted in the mixed pattern, he says. The payoff, he adds, is easy to measure for farmers: "more rice and more money."

—DENNIS NORMILE

MICROBIOLOGY

A Weak Link in TB Bacterium Is Found

Easily the most successful human pathogen in the world, the bacterium that causes tubercu…losis infects one-third of the world's popula…tion. Often acting in deadly combination with AIDS, TB kills 2 million to 3 million people per year, more than any other infectious dis…ease. The secret of the pathogen's success is that it can linger undetected in the lungs for decades, hiding from the macrophages that aim to chew it up and spit it out. Now a team of researchers has uncovered a vulnerability in this resilient bug that suggests new ways to starve it out of its bolt-hole.

When *Mycobacterium tuberculosis* infects a person for the first time, it proliferates for a few weeks until the immune system marshals its defenses. The two then reach a stalemate, says John McKinney of The Rockefeller Uni…versity in New York City, part of a four-institution team re…porting its findings in the 17 August issue of *Nature*. This persistent state—the pathogen population doesn't increase, but the immune system can't get rid of the bacteria already ensconced—can last a life…time, with the person suffering no obvious ill effects. But in 10% of those infected, TB will erupt into full-blown disease in response to various stresses or if the immune system is compromised.

During its latent days in…side macrophages, the bacteri…um is stuck with a restricted diet: It eats carbon from lipids via a pathway called the gly…

Stealth invader. …side the macro… bacteria (black, a… cause devastatin… to the lungs (*abo…*

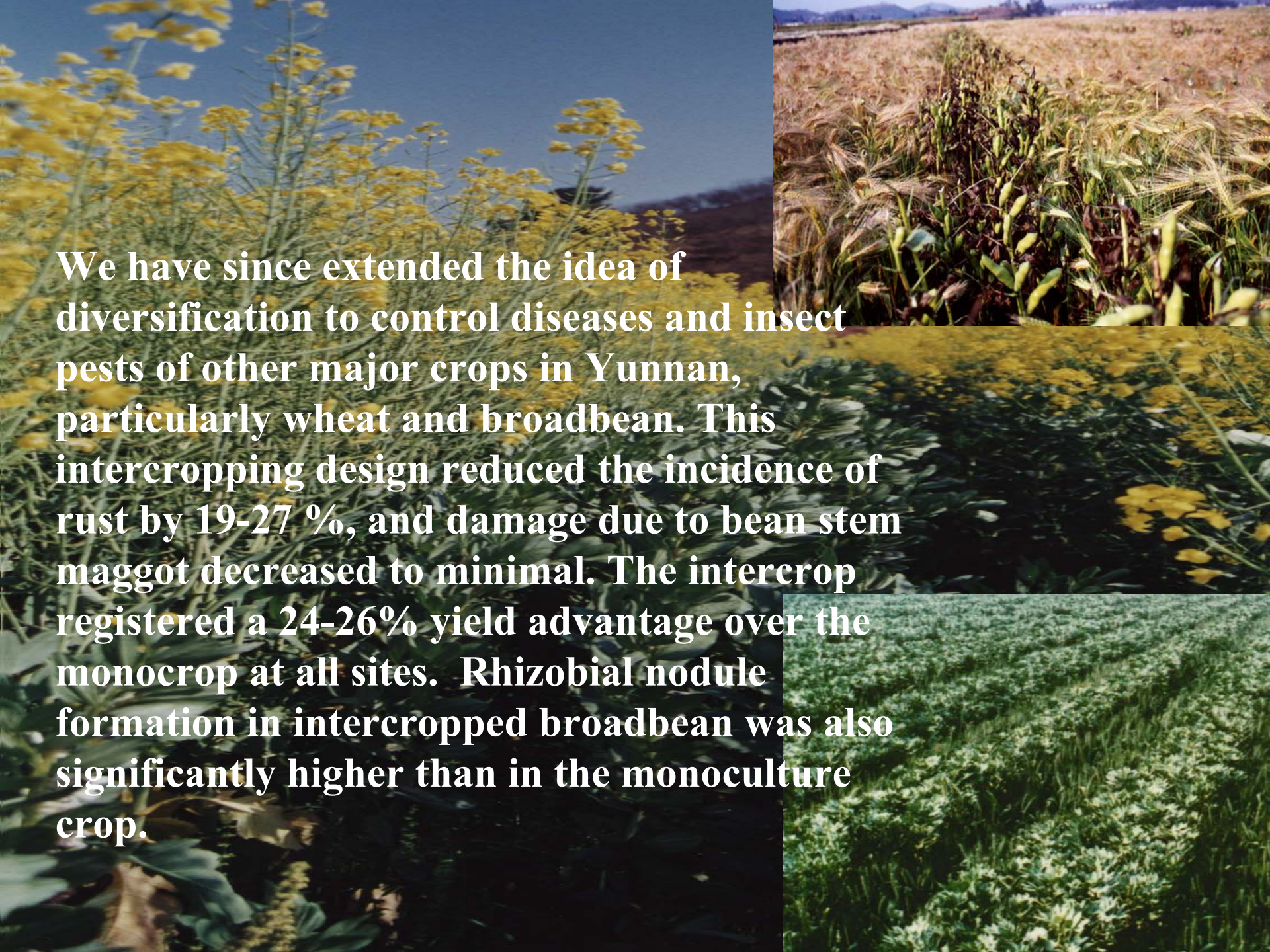
2000.8.17.英国《自然》□表□□

2000.8.18.美国《科学》□表□□

70,000 farmers were Trained

1999.7.13-15 Kunming International workshop on diversity for sustainable crop diseases

2000.8.21-23 Kunming International workshop on diversity for sustainable crop diseases



We have since extended the idea of diversification to control diseases and insect pests of other major crops in Yunnan, particularly wheat and broadbean. This intercropping design reduced the incidence of rust by 19-27 %, and damage due to bean stem maggot decreased to minimal. The intercrop registered a 24-26% yield advantage over the monocrop at all sites. Rhizobial nodule formation in intercropped broadbean was also significantly higher than in the monoculture crop.

This intercropping design of corn and peanut reduced the incidence of corn northern leaf blight and corn southern leaf blight by 35-56 %, and a 8-12% yield advantage over the monocrop at 5 sites of 1320 ha in Yunnan. An extensive network of researchers and extension personnel is being formed in Yunnan to disseminate this technology to farmers.

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Thanks