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EMERGING DISEASE PROBLEMS IN KOREAN RICE AND THEIR ORIGINS[1]

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As the technology of rice production in Korea has rapidly developed and progressed over the last few years, many problems in rice production have been solved. But with the introduction of new genetic material, the increased use of pesticides, higher fertilizer rates and closer plantings, new problems are beginning to emerge. The brown plant hopper outbreak in 1975 resulted to a great extent from some of the changes in management practices. Some rice diseases and nutritional problems that have existed in Korea but have not been considered of serious consequence, are now becoming increasingly severe and possibly as limiting as the hopper outbreak in 1975. Other diseases and nutritional problems are completely new and their cause and significance have not yet been adequately defined.

In this discussion there is no intention to state, nor is there evidence to support a statement, that any of these problems are going to be limiting factors in the future production of rice on the Korean peninsula. Rather this is an attempt to bring together some of the current field problems in Korean rice so that they can be discussed and where necessary receive suitable consideration for research and control.

COLD DAMAGE(Physiological)

In 1972 many of the Korean varieties developed from indica types were severely effected by low temperatures. During the period from 1972 to the present the Korean agri-system has fully developed the use of vinyl tunnels to protect the early planted cold-sensitive seed beds. Cold damage can also effect plant during flowering and reduce yields (19, 24, 25).

Cold symptoms appear to be expressed in two distinct ways in the seed bed:

a. When exposure to cold has been gradual, the plants will show a yellowing and in some instances a whitening of the outer leaves.

b. When exposure has been abrupt, such as an unexpected drop in temperature below 10—12°C after the vinyl convering has been removed, a red bronzing and spotting similar to iron toxicity symptoms will develop in addition to the yellowing.

Present indications are that such cold-effected plants recover adequately if the temperature drop during this seedling stage has not been severe or prolonged. Cold damage during flowering can result in sterility (24, 25) also causing yield losses.

HEAT DAMAGE(Physiological)

With the use of vinyl to protect the cold-sensitive early-seeded varieties, some instances of seedling burn

1) Based on a seminar presented to The Institute of Agricultural Science (IAS), Suweon, Korea, May 16, 1975. The author appreciates the support and contributions of his colleagues in the Institute and especially Dr. Hyuen Park, Plant Physiologist, IAS, who contributed much to the author's knowledge and the discussion of physiological problems of rice.

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have developed. This burn has happened where vinyl was laid flat or if tunneled, was not properly aerated on excessively hot days.

Heat damage symptoms appear as a scorching or reddening and wilting of the leaves. Removal or lifting the vinyl edges on very hot days will generally prevent this temperature build up to the point where damage occurs. Sprays of ascorbic acid have in some instances prevented heat damage (Dr. H. Park personal communication with Dr. Otta).

IRON CHLOROSIS (Physiological)

Traditionally Korean farmers have put ash or charred rice husks on their seed beds to increase heat absorption. Such action in areas where seed are on high pH soils further increases the pH to the point where the iron is tied up and made unavailable to the plant (2, 26) thus resulting in an iron deficiency problem[1].

Such iron deficient seedling show initially as a yellowing of the newer leaves to intense whitening if the condition is not corrected (10, 26). Under normal circumstances the plants will recover; nevertheless, some damage will have been done (9). In very severe circumstances the condition can be corrected by applying ferric sulfate at rates of 200 to 1,000kg/ha (17) in the field or spraying ferrous sulfate on the seed bed (10)[1]. In the Pyeongtaek area, seed beds amended with red soil prevented iron chlorosis symptoms from developing on "Yushin" rice. The Tongil and Tongil-derived rice varieties are known (Dr. H. Park unpublished data) to be more sensitive to high pH and the resultant iron chlorosis than most of the Korean tradtional rice varieties[2].

REDUCTION DAMAGE (Physiological)

In many instances in Korea, rice plants will be found to be adversely effected by high water temperature and low oxygen due to poor drainage two or three weeks after transplanting. When examined these plants frequently show a bronzing or iron toxicity symptom. High yielding Tongil lines appear more susceptible and show stunting and a severe red discoloration of the leaf blades. Conditions favoring this soil reduction disorder are low potassium and zinc with a high pH and high iron content (300 ppm and higher in the leaf). Frequently the symptoms will appear as a yellow orange coloration with the stunting and a consequent lowering of yields. Blackened roots will often be present indicating hydrogen sulfide damage produced under reductive conditions.

This condition is similar to "Akagare" disease (9, 26) and the use of resistant varieties and draining of the paddy to restate oxidative conditions to the soil are ways of correcting this localized problem (9, 26). Dr. H. Park (personal communication) has also suggested the use of potassium and zinc sulfate sprays as a method for correcting this condition[2].

EARLY SENESCENCE[1] (Physiological)

Under Korean conditions high yielding indica lines show very rapid senescence of the upper leaves, especially the flag leaf. Leaves turn yellow to reddish brown from the tip and become dessicated. This may be due to a very rapid translocation of the photosynthate by the leaves. Such rapid leaf senescence seems to be a major cause of some instances of Tongil low yields due to a low filled-grain ratio. Prevention of this early senescence could greately contribute to yield increases by creating a higher filled-grain ratio(21).

RED SPOT (Unknown)

A new leaf spot condition was observed in 1974 and possibly earlier. Samples were principally collected on Tongil. No pathogenic organisms have yet been isolated (I.A.S. unpublished data) and present physiological explanations are not available (Dr. H. Park, personal communication).

Leaf spots are rectangular running with the veins, uniformly brick red in color and larger than leaf spots

1 Yoshida, Shouichi. 1974. Minor Elements for Rice. Unpublished seminar notes. Food & Fertilizer Technology Center, ASPAC, Taipei, Taiwan, Dec. 2—5, 1974.

2 Based on observations of Dr. H. Park, I.A.S. Plant Physiologist, Suweon, Korea.

normally caused by *Helminthosporium oryzae.*

Prevalence and area of occurrence of this condition has not presently been well defined in Korea. Although it is possible that the leaf spots are early or hypersensitive reactions to *Rhynchosporium oryzae*(scald disease discussed below), there is insufficient information as to the distribution and frequency of this condition and there are no experimental observations to support a conclusive diagnosis.

SEEDLING REDDENING(Unknown)

This condition is apparently a genetic condition where individual plants develop a reddish orange coloration but no other abnormal symptoms arise. Plants evidently recover adequately by flowering but grain yield is poor. Little is known about this condition and only preliminary local work has been undertaken by the plant physiology group in I. A. S. (Dr. H. Park, personal communication). The similarity of this condition to the transitory yellowing virus disease found in Taiwan has been noted by both Dr. Shikada (personal communication) and the author but there presently are no pathological studies to clarify this point.

BROWN SPOT(*Helminthosporium oryzae*)

Brown spot ((*Helminthosporium oryzae*) has not been considered a problem in Korean rice culture in recent years. In 1975 many fields of Yushin, a Tongil-derived rice being widely promoted, showed very severe damage due to brown spot. The leaf spot were typical in morphology but were much larger and extensive. This would appear to be purely a matter of susceptibility and an increase in the use of this variety will undoubtedly result in this disease becoming a significant factor in limiting future yields.

STACKBURN DISEASE (*Alternaria padwickii*(Ganuly) Ellis)

This is a seedling blight that is becoming increasingly frequent in Tongil varieties. Kang and Lee (12) have shown that *A. padwickii* is much more prevalent in discolored Tongil seed than in traditional varieties. Although the symptoms on mature plants are rarely seen and presently do not appear to constitute a threat, no information on the amount of damage caused to the seed bed is available in Korea. Scientists in other countries report such damage to be considerable (19).

Stackburn symptoms show as large, oval or circular leaf spots, with dark brown, relatively narrow and distinct margins which circle the spots like a ring. Dark brown to black spots form on seedling roots and coleoptiles and frequently coalesce. Heavily infected seedlings eventually wither and die; less severely affected seedlings may outgrow the disease (18, 19). The fungus was formally called *Trichoconis padwickii* but Ellis has recently transferred the species to *Alternaria* because of its colored conidia and the way conidia are formed (7, 18).

There is little to no information available on control by resistant varieties or chemicals. Kang and Kim(12) have reported some benefit with Hinosan Ec and Kasugamin Ec applied at the panicle emergence or the milk ripening stage.

DOWNY MILDEW(*Scleropthora macrospora* (Sacc.) Thirum., Shaw and Naras)

This disease caused by *Scleropthora macrospora* has been known in Korea for some time but has never assumed significance. In 1974 it was widely found affecting Tongil by Chung et al (3). Considerable damage was also observed in 1975 and large areas had to be replanted to non-Tongil derived varieties in the SW part of the country. The causal agent has been called *Sclerospora macrospora* nd *Phytophthora oryzae* or *P. macrospora*(18). In 1953 it was put into a new genus *Sclerophthora*, which has a sporangial stage like *Phytophthora* and an ögonial stage like *Sclerospora.* Waterhouse (27) and Taso (personal communication) both prefer to retain this fungus in the genus *Phytophthora.* Taxonomy of this fungus has been reviewed in detail by Akai and Fukutomi (1).

The symptoms of the disease first show on new leaves as chlorotic, yellow or whitish spots or patches. In severe cases, leaves may be distorted or twisted with the most severe symptoms showing at flowering when the panicles become irregular, distorted and occasionally spiral. Little is known of the life cycle in Korea, but Japanese workers (18) considered wild grasses as an important source of primary inoculum. Usually the disease warrants no special control measures but disappears when the temperature rises above 35°C (18). Little is known about varietal resistance although the fungus has a host range including 43 genera in the Gramineae.

SCALD DISEASE (*Rhynchosporium oryzae* Hashioka and Yokogi)

This disease was identified in Japan in 1955(8) and has been known in Korea for some time. In recent years scald has assumed more importance because of reports of severe damage on IR-8 derived varieties (6, 13, 14, 15, 22). In 1973 it was reported as a new disease of rice in Korea caused by *Fusarium nivale* (13, 14). It is now apparent that this report was incorrect. (W. Snyder and M. C. Rush, personal communication, 16). Other workers (6) have also had difficulty in putting this organism in the proper taxonomic slot. Of upmost importance, however, is that all authors agree that this disease is on the increase. M.C. Rush (23) in fact observed and described the disease on rice in the United States for the first time in 1973 and recently reported it to be very severe in Louisiana rice in 1975 (personal communication). This heretofore weak parasite potentially may be of severe consequence to Tongil lines in Korea. The author's own observations in Korea would support this possibility. James (11) working with a similar organism, *R. secalis*, has shown in his crop loss assessment work that when the flag-leaf is 100% infecteed, 62% loss in field yield is possible. Scald of rice develops late in the season but does considerable damage to the flag, second and third leaves, just as *R. secalis* does during this same period.

The disease under Korean conditions and on Tongil begins on mature leaves as a greyish brown spot at the margin or more often at the tip. The spot enlarges showing a characteristically concentric pattern of light brown and dark brown circles. This symptom, although not always readily apparent, is diagnostically conclusive. Frequently only a large greyish gravelly looking spot will be apparent. No conclusive work has been carried out on varietal resistance, but the Tongil and Tongil derived lines are being much more heavily attacked than any of the traditional Korean sources that are without IR-8 germ plasm. Preliminary work (Kang and Kim, personal communication) shows promising results from using broad spectrum fungicides such as Dithane M-45, Difolatan or Topsin-M.

SHEATH BLIGHT (*Corticium sasakii* (Shirai) Matsumoto)

This disease or a very similar disease is found many places in the world. In the Philippines and elsewhere it is generally considered to belong to a fungus of the *Rhizoctonia solani* group while in the U.S.A. there is additionally a report of *R. oryzae.* Ou (18) reports that the economic importance of the disease is increasing due to increased fertilizer requirements and the increased plantings of new high-yielding varieties. Ou's findings are supported in Korea by observations of I.A.S. staff and the author (I.A.S. unpublished data).

The disease causes characteristic spots, ellipsoid or ovoid and greenish grey on the leaf sheaths. The spots may get up to 3 cm in length becoming irregular and greyish white with a brown margin. The spots are first formed near the water line but later may be formed on upper leaf sheaths and on the leaf blades.

Chemical control in the past has concentrated on the use of polyoxin and neoasozine. Excessive (7 to 8 or more) applications are being presently used to keep the disease in check, and chemical control under these conditions does not appear promising.

TONGIL STUNT (Black-streaked dwarf virus)

A disease observed since 1973 in Seonsan Gun and possibly elsewhere has been progressively encountered during the 1974 and 1975 seasons. The disease presently appears to be limited to Tongil lines and is potentially very damaging. Plants are severely stunted and generally dark green. There is a severe reduction in yield and frequently excessive tillering develops. Occasional plants show leaf striping symptoms resembling those produced by rice stripe virus. This last symptom and the lack of any laboratory diagnostic work complicated the diagnosis of this disease until mid-1975 when Dr. Hori from Japan demonstrated the presence of white to black streaks on the main stems under the leaf sheaths. Upon examination these streaks are seen to be phloem galls characteristic of those found associated only with the black-streaked dwarf virus in Japan. An initial report (4) was made based on Dr. Hori's finding in late 1975 confirming this diagnosis and conclusively showing the morphology of the phloem gall formations.

The disease had been known to be present only in Japan until 1975. Therefore, this was the first time that the disease was reported outside of the Japanese islands; quite possibly it will spread to other areas in the future. The vector that is principally involved is *Laodelphax striatellus*; thus the stripe symptoms found associated with some of the affected plants are more likely the result of mixed infections by the black-streaked dwarf and rice stripe viruses.

At the present time almost nothing is known about the disease under Korean conditions. The present association of the disease with only Tongil lines should be investigated as well as the distribution of the disease within the country. Laboratory confirmation of the diagnosis should be given high priority to adequately support the present diagnosis which is based solely on symdtoms.

Due to the extremely high populations of *Laodelphax striatellus* (smaller brown plant hopper) frequently encountered in Korea, black-streaked dwarf virus poses a potentially significant problem with the wider planting and intensification of Tongil lines in rice growing areas on the Korean penninsula.

ORIGINS OF CURRENT FIELD PROBLEMS IN KOREAN HIGH YIELDING RICE VARIETIES.

In any rapid expansion and development of new varieties programs, serious problems can arise. Korean's programs are no exception. Rice culture in Korea has progressed at an outstanding rate and truly remarkable achievements have been made. But in making these achievements, cultivation and management practices sometimes have not changed and in other instances have changed drastically. The continued use of ash on seed beds resulting in iron chlorosis problems is a good example of lack of change. The indica-derived varieties are very sensitive to high pH and with the introduction of vinyl seed bed coverings-a drastic change of management practices—there was an interaction that led to iron chlorosis problems because there was no need to continue the use of ash cover in the seed beds when covered with vinyl.

Other problems are more subtle and more intricately associated in their contribution to emerging problems. Three areas that are critical should be given special consideration. These are:

a. gene protection

b. overdeployment of uniformly genetic material and

c. genetic vulnerability

GENE PROTECTION

During discussion sessions on genetic vulnerability at the 1975 annual meetings of the American Phytopathological Society, Dr. Scott Abney raised the point that control systems should be continued even though somewhat moderated when resistance is developed in a crop. These control practices strategically manipulated will provide "gene protection". Therefore, to prevent selection of virulent pathogen strains and the breakdown of specialized resistance in a crop as well as to prevent minor diseases from developing into major diseases(probable the principal cause of increases in downy midew and scald as well as other fungus diseases), chemical control must be continued. Even though the number of applications will be greatly decreased, the importance of the applications and their timing assume an increasingly cirtical role. In this manner, the principal of "gene protection" becomes a focal point in preserving resistance and the value of resistance in integrated control program.

Gene protection should be given attention in Korea because it has been shown that there are strains of the blast fungus that are virulent to Tongil (5). The emergence of minor diseases such as downy mildew, scald, stackburn and others as potentially significant diseases additionally necessitates the study of the gene protection approach as a cirtical area for future study.

OVERDEPLOYMENT OF UNIFORMLY GENETIC MATERIAL

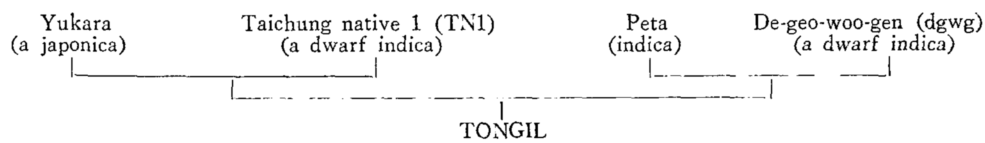
Korea's rice target for 1976 is 60% planting of *Tongil* and *Tongil*-derived varieties. There are potential problems in such vast planting of uniformly genetic material. In such instances high positive selection pressure is put on disease and insect survival mechanisms for resistance. History has shown the pitfalls of such situations—the potato famine in Ireland, the coffee rust epidemic in South America, and even the corn blight epidemic in the U.S.A. There are too many unknowns related to disease and insect problems with Tongil and Tongilderived rice varieties to allow such vast plantings to take place. The 1975 brown plant hopper outbreak should alert us to the need for caution.

GENETIC VULNERABILITY

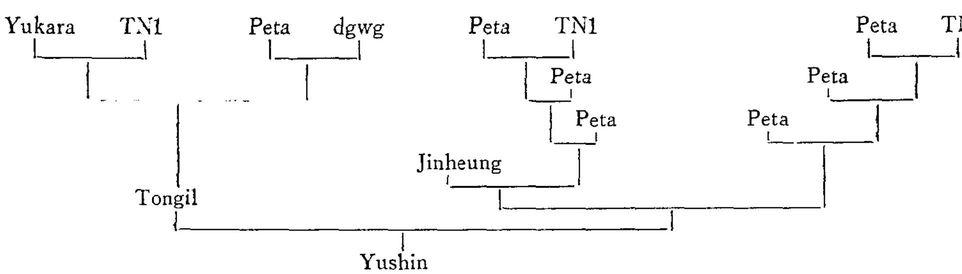
Many people have pointed out that there is extreme genetic vulnerability in Korean "wall to wall crops" when a trend develops to over-utilize genetically uniform material. Of special interest to the author and his colleagues was Dr.S.H. Ou's comments at the American Phytopathological Society meetings in the same session addressed by Dr. Abney. Dr. Ou outlined the parentage of the IR-8 rices and their derivatives and showed the consistency with which certain materials where used. The variety Peta has been used consistently in developing the IRRI high yielding rices.

In discussing the potential of genetic vulnerability in high yielding Korean rice, it is wise to begin with this indica rice, Peta. It is a variety with many desirable characteristics and much fovored by rice breeders. But like the story of the "T" cytoplasm in the Texas male sterile corn that precipitated the great corn blight epidemic in the U.S.A., what would happen if there is a disease or insect that rice with gene source is especially vulnerable to? We do not know. Why has IR-8 been so vulnerable to scald in recent years? Change in management practices or genetic vulnerability? This area should receive high level priority for study.

In Korea, Tongil rice and its derivatives are an outstanding example of over deployment of an excellent variety. Tongil has predominantly indica parentage being derived from IR-8, thusly:



Yushin has been pointed to as the major variety to be developed that will be cropped as a compliment to Tongil. The author has been assured that there is really very little similarity to Tongil in Yushin. This is difficult to appreciate when Yushin is seen to have a very heavy indica parentage that is predominately Peta!



Not enough is known about the vulnerability of Tongil and Yushin. This much is certain: there is a high amount of uniformity in the parentage and too many unknowns with respect to the various diseases previously described. These varieties are being planted to far too much acreage to be safe with such limited knowledge. A reappraisal of the promotion of these materials is critically necessary.

In 1975 the brown plant hopper caused considerable damage and concern to the Korean rice agrisystem. This should certainly have alerted responsible officials to the potential damage that can come from pests and diseases. A proper perspective of rice management for Korea, or any other country for that matter, should be established that will focus on development of the high yielding varieties and on the integrated management practices that include pest and disease management through the strategic use of chemicals and diversified variety deployment.

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