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IR42: A RICE TYPE FOR SMALL FARMERS OF SOUTH AND SOUTHEAST ASIA

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IR42: A RICE TYPE FOR SMALL FARMERS OF SOUTH AND SOUTHEAST ASIA[1]

ABSTRACT

Small farmers of South and Southeast Asia often lack the resources to provide the water control and the management inputs needed to get high yields with modern rice varieties. To join the *green revolution* in rice, they need modern varieties with built-in tolerance for adverse environmental factors such as too little or too much water, diseases and insects, nutrient deficiencies, and soil toxicities.

IR42, a Philippine-named variety, is the closest to meeting farmers' needs. It has good agronomic characteristics and moderate drought and submergence tolerance. It has resistance to the major diseases and insects that attack rice. It yields well at low levels of nitrogen and phosphate fertilizers and has moderate tolerance for salinity, alkalinity, iron toxicity, boron toxicity, excess organic matter, and zinc deficiency.

In field tests in the Philippines, IR42 outyielded most IRRI varieties and elite lines on nutrient-deficient or toxic wetland rice soils and responded well to moderate applications of nitrogen and phosphorus fertilizers. In tests in South and Southeast Asian countries it outyielded IR8 and ranked among the three top yielders.

[1]By F. N. Ponnamperuma, principal soil chemist, International Rice Research Institute, Los Baños, Laguna, Philippines. Submitted to the IRRI Research Paper Series Committee November 1979.

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IR42: A RICE TYPE FOR SMALL FARMERS OF SOUTH AND SOUTHEAST ASIA

The introduction in 1966 of the fertilizer-responsive variety IR8 ushered in the era of *miracle rices* and predictions of self-sufficiency in food production for many developing countries (FAO 1970). But barely a decade later, the International Food Policy Research Institute (1977) warned that rice production was not keeping pace with population growth and that by 1990 major rice-importing countries would have to increase their imports, whereas exporting countries would have to import rice. More recently the Asian Development Bank (1979) forecast a severe food shortage in Asia in the 1980s.

The forecasts of food shortage came because the *green revolution* of the 1960s bypassed many farmers.

> "For about three farms out of four there are no improved varieties or technology that can significantly increase current levels of production." (IRRI 1976)

Thus, in vast tracts in South and Southeast Asia with poor water control or injurious soils, farmers have not accepted the new varieties (Asian Development Bank 1979). Even when the new varieties are grown, national yields are about a third of experimental yields. In the Philippines, where 75% of the farmers use the modern varieties, the national yield is less than 2 t/ha (Brady 1977), compared with experimental yields of 5.3-6.8 t/ha. Herdt and Barker (1977) and Herdt and Wickham (1978) have attributed the yield gap to environmental and management differences. Both environmental and management problems affect the small farmer severely because he lacks the resources to change the environment or to provide the inputs necessary for high yields. Small farmers often lack the resources to provide the water control, soil amendments, fertilizers, and pesticides necessary to get high yields from the modern varieties.

The main adverse components of the small farmer's rice environment include:

- too little or too much water,
- diseases,
- insect damage,
- deficiencies of nitrogen, phosphorus, and zinc, and
- soil toxicities, such as salinity, alkalinity, strong acidity, iron toxicity, boron toxicity, and excess organic matter.

Because the small farmer cannot afford to change the physical environment to suit the modern varieties, rice scientists must tailor the variety to fit the environment. In other words, breeders must build into the variety tolerance for as many adverse factors as possible -- a major objective of the Genetic Evaluation and Utilization program of the International Rice Research Institute (IRRI 1975).

IR42, a variety named by the Philippine Seed Board in 1977, is the best modern rice for small farmers to date because it combines the desirable agronomic characteristics of the earlier improved varieties with drought and submergence tolerance, disease and insect resistance, and tolerance for nutrient deficiencies as well as soil toxicities. Rice types such as IR42 will enable small farmers to obtain stable yields in unfavorable environments (Mahadevappa et al 1979).

AGRONOMIC AND GRAIN CHARACTERISTICS OF IR42

IR42 (IR2071-586-5-6-3) has intermediate height (105 cm) and growth duration (130 days). Its parents are IR1561-228-3-3/IR24^4/*Oryza nivara*//CR94-13. It has seedling vigor and a high tillering capacity and demonstrated its high yield potential when it yielded 8 t/ha at IRRI in the 1977 dry season (IRRI 1978).

IR42 is a medium-grained, high-amylose rice with a relatively good appearance.

DROUGHT AND SUBMERGENCE TOLERANCE OF IR42

One third of the world's rice land is rainfed and most of the rainfed rice is grown in South and Southeast Asia. Of the 40 million hectares of rainfed rice in South and Southeast Asia 20 million are subject to flooding to a depth of 1 m (Barker and Herdt 1979).

Drought

The uncertainty and inadequacy of rainfall in rainfed areas render rice yields highly unstable (Krishnamoorthy 1979). IR42's moderate drought tolerance (IRRI 1978) makes it better suited to rainfed areas than earlier improved varieties.

Submergence

In half the rainfed area, flooding to a depth of 1 m is a serious obstacle to rice production. Submergence tolerance is a desirable trait for varieties bred for such areas. IR42 has moderate submergence tolerance. It yielded 3.15 t/ha in an experiment in which it was submerged in water 40 cm deep from 12 days after transplanting until harvest (B.S. Vergara, IRRI, 1979, personal communication).

Practical implications

Drought and submergence tolerance make IR42 more suited than its precursors to rainfed areas.

DISEASE AND INSECT RESISTANCE OF IR42

The susceptibility of the early modern varieties to diseases and insects contributed to their loss of popularity among small farmers.

Disease

IR42 is resistant to blast, rice tungro virus, rice grassy stunt, rice ragged stunt, and bacterial leaf blight; it has intermediate resistance to sheath blight and *Cercospora* leaf spot (IRRI 1978, Khush 1978). It is, however, susceptible to Bakanae (L. D. Haws, IRRI, 1979, personal communication).

Insects

IR42 is resistant to biotypes 1 and 2 of the brown planthopper and to the green leafhopper. It is moderately resistant to the stem borer (Khush 1978).

Practical significance

IR42's resistance to such a wide range of diseases and insects will help the small farmer, without the costly input of chemicals, to avert the heavy toll that diseases and insect pests usually take of his crops.

TOLERANCE OF IR42 FOR NUTRIENT DEFICIENCIES

One advantage that the modern rice varieties have over the traditional ones is their fertilizer responsiveness. But the small farmer often cannot afford the quantities of fertilizer required for yields of 8-10 t/ha or more that the modern varieties can produce. He needs a variety that will give a moderate yield with a moderate amount of fertilizer. A variety that can exploit and utilize both soil and fertilizer nutrients efficiently can fulfill that need.

IR42 is such a variety. In field experiments, it has shown tolerance for nitrogen, phosphorus, and zinc deficiency as well as marked positive responses to moderate applications of nitrogen and phosphorus fertilizers.

Nitrogen deficiency

Nitrogen deficiency is the most important nutritional factor limiting the yield of wetland rice. Most rice lands in South and Southeast Asia except those of Malaysia are nitrogen-deficient (Kawaguchi and Kyuma 1977). In the Philippines, 162 out of 367 samples of wetland rice soils analyzed contained less than 100 ppm of available nitrogen (Ponnamperuma 1978a).

Although nitrogen fertilization is the best method of increasing the productivity of nitrogen-deficient soils, fertilizer is often not available in time or is applied incorrectly or at the wrong time. Besides, the efficiency of fertilizer nitrogen in wetland rice fields is low (Mitsui 1956). In addition, in many South and Southeast Asian countries the cost of fertilizer relative to that of rice is unfavorable (Ruttan 1978), which discourages fertilizer use by small farmers.

Varieties that extract and utilize soil and fertilizer nitrogen efficiently will enable small farmers to obtain yields of about 5 t /ha without using large amounts of nitrogen fertilizer. Although the existence of such varieties was reported (IRRI 1977), IR42 is the first improved variety to demonstrate nitrogen efficiency in the field.

IR42 yields well in the wet season, an advantage because most of the rice in South and Southeast Asia is grown in the wet monsoon. Its performance at low fertilizer levels in tests at experiment stations and in farmers' fields prompted the comment "The consistency of IR42's relatively high yield without nitrogen fertilizer makes it a valuable variety for low-fertility conditions." (IRRI 1978) IR42 greatly outyielded two earlier modern varieties, IR8 and IR26, at 0 and 60 kg N/ha in the 1977 dry and wet seasons at IRRI (Table 1). It also gave high yields in farmers' fields at 0 and 60 kg N/ha: the average yields of IR42 without nitrogen fertilizer at three sites in Laguna province in 1978 were 5.1 t/ha in the dry season and 5.8 t/ha in the wet season compared with IR8's 4.7 t/ha and 4.8 t/ha (IRRI 1978, Khush et al 1979).

In a yield trial with 5 varieties on Maahas clay (pH: 6.3, O.M.: 1.5%, total N: 0.18%, Olsen P: 9 ppm, exchangeable K: 1.0 meq/100 g) with no N, P, K fertilizer, IR42 gave the highest yield of 4.6 t/ha (Table 2).

The nitrogen efficiency of IR42 will be a great boon to the small farmers of South and Southeast Asia where most rice lands are nitrogen-deficient and where most rice producers cannot afford large amounts of fertilizer.

Phosphorus deficiency

Phosphorus deficiency limits rice yields on Andosols, Oxisols, Ultisols, Vertisols, Histosols, and acid sulfate soils. Some of these soils are deficient in available phosphorus; others convert phosphate fertilizer into highly unavailable forms. Phosphorus deficiency in rice lands is widespread in Asia (Tanaka and Yoshida 1970, Goswami 1975, Kawaguchi and Kyuma 1977). In the Philippines 23 soil types are phosphorus-deficient (PCARR 1978). Rice varieties that can exploit soil and fertilizer phosphorus efficiently will enable farmers to obtain good yields on phosphorus-deficient soils with moderate amounts of phosphate fertilizer and on marginally deficient soils with no fertilizer. Such varieties contribute 0.5 to 0.8 t/ha toward yield stability (Mahadevappa et al 1979).

Table 1. Performance of three rice varieties in irrigated fields at two nitrogen levels. IRRI, 1978.

Variety	Dry season (kg N/ha)		Wet season (kg N/ha)	
	0	60	0	60
IR42	5.1	6.7	4.8	5.7
IR26	4.0	6.0	1.3	1.0
IR8	2.3	3.9	0.5	0.6

Table 2. Performance of five varieties, without N, P, K fertilizers, on Maahas clay. IRRI, 1978 dry season.

Variety	Grain yield[a] (t/ha)
IR42	4.6 a
IR36	3.5 b
IR38	3.2 b
IR40	2.1 c
IR34	1.2 d

[a]Yields followed by a common letter are not significantly different at the 5% level.

Although rated as moderately tolerant of phosphorus deficiency, IR42 yielded 3.9 t/ha, compared with tolerant IR20's 4.2 t/ha, without phosphorus fertilizer on a phosphorus-deficient soil (Luisiana clay: pH, 4.8; Olsen P, 5 ppm) in Laguna province, 1978 dry season. With 20 kg P/ha as superphosphate, IR42 increased its yield to 4.9 t/ha compared with IR20's 4.8 t/ha.

IR42 apparently can extract and utilize both soil and fertilizer phosphorus efficiently. It should appeal to the small farmers who usually use little or no phosphate fertilizer.

Zinc deficiency

Zinc deficiency is a widespread nutritional disorder of wetland rice in South and Southeast Asia. It occurs on alkali soils, calcareous soils, poorly drained mineral soils, and organic soils (Castro 1977, Orticio and Ponnamperuma 1977). Experiments in farmers' fields have confirmed the widespread occurrence of zinc deficiency in the Philippines and about 2 million hectares of current and potential rice lands in the Philippines may be zinc-deficient.

IR42 can contribute 0.5 to 1.5 t/ha toward yield stability because of tolerance for zinc deficiency (Mahadevappa et al 1979). Trials conducted by the Philippine Bureau of Soils in 1976 (17 farms in 11 provinces, UPLB-CA Crops and Soils Extension Office 1977) revealed an average yield increase of 0.57 t/ha when zinc oxide was used in addition to N, P, K fertilizers. For 2,000 farm trials and more than 10,000 extension demonstration plots during a 3-year period, Bautista et al (1979) reported an average increase of 0.65 t/ha where zinc was applied.

Because zinc deficiency is common and its incidence is likely to increase, varieties with tolerance for zinc deficiency will enable small farmers to avert zinc deficiency without zinc application on marginally zinc-deficient soils and with small zinc applications on soils that are strongly zinc-deficient.

Although rated as only moderately tolerant of zinc deficiency, IR42 yielded 5.4 t/ha compared with tolerant IR34's yield of 5.0 t/ha on Buayan clay loam (pH: 7.9, O.M.: 7.6%, available zinc: 0.03 ppm) partially amended with zinc, in South Cotabato province, 1978 dry season.

Practical implications

Most rice lands in South and Southeast Asia are deficient in nitrogen, phosphorus, and zinc. Often the small farmer is unaware of the existence of those deficiencies. Even when he recognizes them, he may not be able to correct them because of lack of cash, high cost or unavailability of fertilizer, and other shortcomings characteristic of rural areas of South and Southeast Asia.

The traditional varieties may have some tolerance for nutrient deficiencies but their yield potential is low. The earlier modern varieties have a high yield potential but low tolerance for nutrient deficiencies. Because IR42 combines high yield potential with the capacity to yield well at low nutrient levels, it is well suited to the small farmers of South and Southeast Asia.

IR42'S TOLERANCE FOR ADVERSE SOILS

Millions of hectares of land in South and Southeast Asia climatically and physiographically suited to rice lie uncultivated or are cultivated with poor results -- usually by small farmers -- because of soil toxicities such as salinity, alkalinity, strong acidity, iron toxicity, and excess organic matter (Ponnamperuma 1978b). Varieties with tolerance for those conditions will enable the small farmers who cultivate such soils (because of land scarcity) to increase yields and to expand the cultivated area without costly reclamation inputs.

Salinity

About 63 million hectares climatically and physiographically suited to rice lie uncultivated or cultivated, with poor results, because of salinity (Ponnamperuma 1978b). In the Philippines there are 400,000 hectares of coastal saline soils (Guerrero 1977). To cultivate strongly saline soils, salt-resistant hybrids, such as IR4630-22-2 or

IR9884-54-3, are necessary. But farmers whose soils are only slightly saline can increase their yields and bring more saline fields under rice by growing IR42. Because IR42 has disease and insect resistance, it is superior to the salt-tolerant varieties currently grown.

The salt tolerance of IR42 enabled it to produce 2.3 t/ha on a saline soil (pH: 7.4, EC_e: 5-8 mmho/cm) in Camarines Sur province, Philippines, where IR26, IR8, and IR30 produced only 1 t/ha each (IRRI 1978). Although IR42 is rated as moderately salt-tolerant, it outyielded several salt-tolerant hybrids and salt-tolerant elite lines in a saline soil (pH: 4.4, EC_e: 2-8 mmho/cm) in Misamis Occidental province, Philippines, reclaimed from a coastal swamp only a year before (Table 3). In a similar test in Agusan del Norte province, IR42 was top yielder (Table 4).

The use of IR42 will confer a yield advantage of 1 to 1.5 t/ha in moderately saline soils.

Table 3. Performance of 10 rices on a saline field at Sinacaban, Misamis Occidental province, Philippines, 1978 dry season.

Variety/line	Grain yield[a] (t/ha)
IR42	5.6 a
IR4630-22-3	5.1 ab
IR2153-26-3	4.7 bc
IR2071-105-4	4.6 bc
IR2071-586-5	4.3 c
IR5657-33-2	4.2 c
IR4573-4-3	4.1 c
IR4432-28-5	4.1 c
IR26	4.1 c
C4-63G	4.1 c

[a]Yields followed by a common letter are not significantly different at the 5% level.

Table 4. Performance of 10 rice varieties on a coastal saline soil, Agusan del Norte, Philippines, 1979 dry season.

Variety/line	Grain yield[a] (t/ha)
IR42	4.3 a
IR2307-247-2	4.0 a
IR364-75-1	3.7 ab
IR4613-54-5	3.2 bc
IR3518-96-2	2.9 cd
IR3880-10	2.7 cde
IR4816-70-1	2.8 cd
IR2071-137-5	2.2 ef
IR34	2.4 de
E425	1.5 f

[a]Yields followed by a common letter are not significantly different at the 5% level.

Alkalinity

Alkali soils cover 6.5 million hectares in the Indo-Gangetic plains in Pakistan and India (Ponnamperuma 1978b). The bulk of that area is uncultivated. IR42 produced 5.2 t/ha on an alkali soil (pH 8.6) in a farmer's field in General Santos, South Cotabato, Philippines (Table 5).

IR42's moderate tolerance for alkalinity and zinc deficiency should enable farmers there to get good yields without heavy inputs or gypsum and zinc sulfate.

Iron toxicity

Iron toxicity is a widespread nutritional disorder of wetland rice in South and Southeast Asia (Tanaka and Yoshida 1970, Ponnamperuma 1978b). In the Philippines, it has been recognized in Albay, Bukidnon, Camarines Sur, Mindoro, Misamis Occidental, and Quezon provinces.

Iron toxicity can be alleviated by liming or drainage -- practices beyond the capability of most small farmers. Varietal tolerance is a simpler solution.

On an iron-toxic soil (pH: 3.7, O.M.: 2.8%, active Fe: 2.2%, active Mn: 0.001%) in Albay province, IR42, although rated only moderately tolerant of iron in the greenhouse, yielded as much as or more than several tolerant lines and outyielded four IR varieties by a wide margin (Table 6).

Boron toxicity

Boron toxicity is a hazard in coastal saline soils and in soils irrigated with saline water (Ponnamperuma and Yuan 1965, Kanwar and Randhawa 1974, FAO/UNESCO 1973). IR42 has moderate tolerance for boron toxicity.

Table 5. Performance of 10 rices on an alkali soil, General Santos, South Cotabato province, Philippines, 1979.

Variety/line	Grain yield[a] (t/ha)
IR42	5.2 a
IR36	5.0 ab
IR2863-38-1	5.0 ab
IR26	4.1 ab
IR46	4.1 ab
IR4227-28-3	4.0 ab
IR2307-217-3	3.8 abc
IR3518-106-2	3.6 bc
IR2153-26-3	2.5 cd
IR9129-393-2	1.2 d

[a]Any two means followed by the same letter are not significantly different at the 5% level.

Table 6. Relative performance of IR42 on an iron-toxic soil, Malinao, Albay, Philippines, 1978 dry season.

Variety/line	Iron toxicity tolerance[a]	Grain yield[b] (t/ha)
IR42	MT	4.5 a
IR4432-52-6	T	4.3 ab
IR2058-78-1	T	4.3 ab
IR32	MT	3.7 bc
IR38	MT	3.0 de
IR20	T	2.8 de
IR36	T	2.5 e
IR26	S	1.4 f

[a]MT = moderately tolerant, T = tolerant, S = susceptible. [b]Yields followed by a common letter are not significantly different at the 5% level.

Table 7. Performance of three varieties and eight elite lines on an organic soil at Colorado, Agusan del Norte, Philippines, in the presence of nitrogen, phosphorus, potassium, copper, molybdenum, and zinc, 1978 dry season.

Variety/line	Grain yield[a] (t/ha)
IR42	4.3 a
IR[illegible]07-137-5	4.0 a
IR3464-75-1	3.7 ab
IR4613-54-5	3.2 bc
IR4422-6-2	3.1 bc
IR3518-96-2	2.9 cd
IR4816-70-1	2.8 cd
IR3880-10	2.7 cde
IR34	2.4 de
IR2071-131-5	2.6 ef
E425	1.5 f

[a]Yields followed by a common letter are not significantly different at the 5% level.

Excess organic matter

Peat lands (Histosols) cover about 22 million hectares of land in Southeast Asia physiographically and climatically suited to rice (Ponnamperuma 1978b). Most of the area is currently under swamp forests. Governments in Southeast Asia are clearing the forests and opening peat lands for food crops.

Rice on peat soils suffers from nitrogen, phosphorus, potassium, copper, molybdenum, and zinc deficiencies (IRRI 1978). Some organic substances present in peat soils may also inhibit grain formation (Driessen 1978). Varieties grown by farmers may tolerate peat soil conditions but they give low yields.

On a peat soil in Agusan del Norte province, Philippines (pH: 6.9, O.M.: 18%, available Zn: 0.1 ppm), with N, P, K fertilizer and micronutrients, IR42 with 6.6 t/ha outyielded IR34, a tolerant rice, and several lines that had previously done well on organic soils (Table 7).

Practical implications

About 100 million hectares of land suited to wetland rice in South and Southeast Asia lie uncultivated or are cultivated, with poor results, by small farmers because of adverse soil conditions. The traditional varieties grown by farmers in these problem areas lack yield potential and pest resistance. The earlier modern varieties lacked tolerance for adverse soil conditions. IR42 combines good agronomic characteristics and pest resistance with tolerance for salinity, alkalinity, iron toxicity, boron toxicity, and excess organic matter. Use of a variety like IR42 will enable farmers to increase yields on current rice fields and expand the cultivated area in those problem lands.

PERFORMANCE OF IR42 IN SOUTH AND SOUTHEAST ASIA

IR42 was one of 21 varieties tested at 21 sites in 8 countries in South and Southeast Asia in 1977 in the International Rice Testing Program coordinated by IRRI. The soils ranged from 4.2 to 8.5 in pH and from sandy loam to clay in texture. Table 8 gives an example of IR42's performance in 1978 Philippine tests. IR42 outyielded IR8 in seven countries (Table 9). It gave the highest yield at three sites and yields that did not differ significantly from the highest in three others (IRRI 1978).

Table 8. Performance of IR42 compared with that of other IR varieties on 6 problem soils, 1978 dry and wet seasons.

Problem	Variety	Rating[a]	Grain yield (t/ha)	Location
Salinity	IR42	MT	5.6	Sinacaban,
	IR4630-22	T	5.1	Misamis Occ.
Iron toxicity	IR42	MT	4.6	Malinao,
	IR36	T	2.2	Camarines Sur
Peat soil problems	IR42	MT	4.2	Colorado,
	IR34	T	2.4	Agusan del Norte
Nitrogen deficiency	IR42	-	4.6	IRRI Farm
	IR34	-	1.2	
Phosphorus deficiency	IR42	MT	3.9	Pangil, Laguna
	IR20	T	4.2	
Zinc deficiency[b]	IR42	MT	5.4	Gen. Santos,
	IR34	T	5.0	South Cotabato

[a]MT = moderately tolerant, T = tolerant. [b]Partly corrected by zinc oxide dip.

In a similar test in 1978 of 28 varieties at 13 sites in 8 South and Southeast Asian countries, IR42 outyielded IR8 in 7 countries. It gave the highest yield at four sites and yields that did not differ significantly from the highest at six other sites (IRRI 1979a).

In the 1977 and 1978 tests in South and Southeast Asian countries, IR42 outyielded IR8 and ranked among the 3 top yielders (Table 10). The reasons are apparent in Table 11.

A RICE FOR SMALL FARMERS

IR8 failed to attract the attention of small farmers, who constitute the bulk of the rice producers of South and Southeast Asia, largely because of adverse physical and biotic environmental factors beyond their control. IR42, by contrast, has resistance to the major rice pests and moderate drought and submergence tolerance. It has moderate tolerance for nutrient deficiencies commonly encountered in the region and does well at moderate fertilizer levels. It also has moderate tolerance for the major soil toxicities. Use of IR42 and varieties of its type will enable small farmers to obtain stable moderate yields and participate in the green revolution in rice.

Table 9. Performance of IR42 and IR8 in 9 South and Southeast Asian countries in the 1977-78 wet seasons.

Country	Mean yield (t/ha)			
	1977		1978	
	IR42	IR8	IR42	IR8
Burma	4.3	3.3	3.6	3.0
Bangladesh	4.9	3.9	4.3	2.3
India	4.5	4.1	4.0	3.4
Indonesia	5.2	-	4.0	3.4
Nepal	5.0	4.8	4.8	4.7
Pakistan	3.9	3.9	-	-
Philippines	5.9	1.3	2.8	3.3
Thailand	5.9	5.2	5.8	4.5
Viet Nam	-	-	4.9	4.2

Table 10. Performance of IR42 and IR8 in 9 South and Southeast Asian countries, 1978 wet season.[a]

Year	Sites (no.)	Entries (no.)	Mean yield			
			t/ha		Rank	
			IR42	IR8	IR42	IR8
1977	21	21	4.9	4.0	2	20
1978	13	28	4.7	3.9	3	22

[a]Adapted from International Rice Testing Program reports (IRRI 1979a,b).

Table 11. A summary of attributes, IR42 vs IR8.[a]

Adverse factor	IR8	IR42
Diseases		
Blast	MR	R
Bacterial blight	S	MR
Grassy stunt	S	R
Tungro	S	R
Ragged stunt	S	R
Insects		
Green leafhopper	R	MR
Brown planthopper	S	R
Stem borer	MS	MR
Nutrient deficiencies		
Nitrogen	-	R
Phosphorus	MR	MR
Zinc	S	MR
Iron	S	MR
Soil toxicities		
Salinity	MR	MR
Alkalinity	S	MR
Iron toxicity	S	MR
Boron toxicity	MR	MR
Peat soil problems	MS	MR
Drought	S	MR
Submergence	S	MR

[a]R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

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