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Current situation of rice production in Portugal
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Abstract. Rice production is still a profitable activity for the Portuguese rice growers. Nevertheless, given the new environmental challenges, it competitiveness would require the use of modern means of production. First of all, it is important to know the present status of the Portuguese rice growing activity. Our purpose is to present a review of the production technology in Portugal and the phytopathological problems involved. We try to show that rice blast (*Magnaporthe grisea* [Hebert] Barr) and stem rot (*Magnaporthe salvinii* [Catt.] Krause & Webster) are the most serious rice diseases. Other pathogens are mentioned, namely the fungi *Cochliobulus myiabeanus* (Ito & Kur) Drechsler ex Dastur, *Rhizoctonia oryzae sativa* (Sawada) Mordue and *Gibberella fujikuroi* (Saw) Wollenw, the nematode *Hirschmanniella oryzae* (Breda de Haan) Luc & Godoy, and the bacterium *Pseudomonas avenae* Manns. Finally, “brança” is discussed as the most important physiological rice disease in Portugal.

I – Current situation

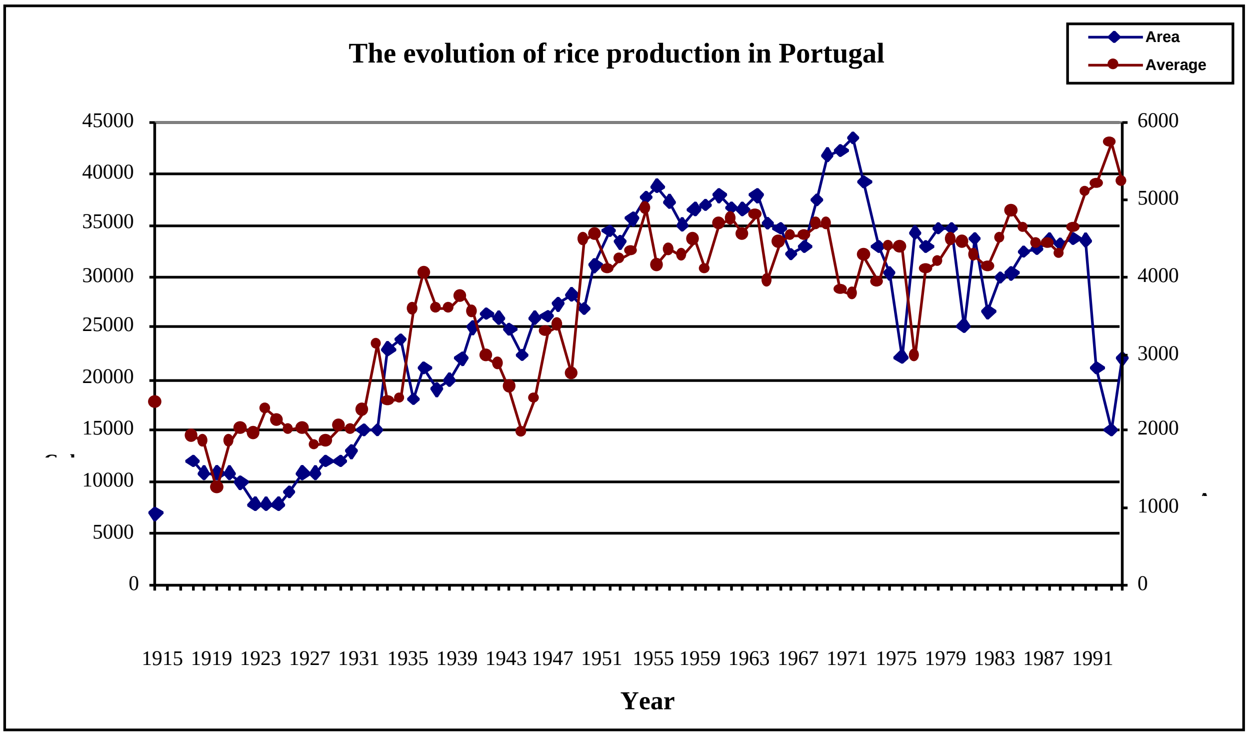
Rice production occupies an enviable position in Portuguese agriculture. It is one of the widely grown crops whose unit production is close to that of the European Community average. Since 1950 the yields have most often been above 4,000 kg.ha^{-1} of paddy rice and tended recently to be higher because of a better selection of growing areas. Nevertheless, yields obtained throughout these years have varied greatly especially because of the variation in the surface area occupied by the crop, which was further determined by the availability of irrigation water (Fig. 1).

Despite Portuguese efforts for rice growing in the last few decades, production technology still undergoes many constraints which prevent the sector from reaching the level observed in countries with a more efficient rice growing sector.

Within the European Union, the Portuguese rice sector is characterized by some specific features. For some population group, rice is a staple food; this accounts for an average annual consumption of 16 kg of white rice per inhabitant. Besides, Portugal's rice production covers only one part of its needs and the Portuguese market is becoming very important in the way of the consumption of Japonica type rice of the Community's production.

In Portugal, rice is grown under a Mediterranean climate with Atlantic influence characterized by a relatively warm and dry growing season. Among other factors, the success of its production depends on climatic parameters such as temperature, water and solar radiation (Pereira, 1989).

Figure 1. The evolution of rice production in Portugal since 1915: Cultivated area (ha) and average crop yield (kg.ha-1).



Source: INE, 1915 ... 1993 ; INE (data not published for 1994).

Currently, the areas in the country that have a potential for rice production have been clearly defined (Faria and Pinto, 1988) and they occupy around 30,000 ha spread along the basins of some rivers located south of the Vouga river. The yields are usually higher as we descend latitude-wise and the better average yields (8,000 to 10,000 kg.ha^{-1} of paddy rice) are obtained in the basins of the Tagus and Sado. However, in the good soils of the Mondego rice production may exceed 6,000 and even 7,500 kg.ha^{-1} and rice fields with less than 2,500 kg.ha^{-1} are found in the basin of the Tagus and Sado.

In Portugal, the effect that temperatures recorded during the crop cycle can have on the development of rice plants or on production is already known.

Beside the effect of temperatures between April and September (Faria and Pinto, 1988), it is known that temperatures can be crucial at three developmental stages (Reis and Gonçalves, 1981; Pereira, 1989): germination, flowering and maturation. At the beginning of the vegetative stage, low temperatures cause problems at germination and of efficiency of herbicidal treatments. At the time of flowering, the low temperatures often recorded at higher latitudes give rise to floral sterility (this can be one of the major causes of what is described here as “brança”).

The importance of water in rice growing in Portugal is twofold:

❑ First, water foreseeable for irrigation. The exact amount of water available determines the surface area to be sown. This area has been greatly reduced in the last three years (1992, 1993 and 1994) and has affected the basins of the Tagus, Sado and Caia (Guadiana). In the Tagus, due to a problem of water salinity, some rice fields were lost in 1992. Water management in Portuguese rice fields has much improved a lot in the past few years and so has the management of the basin. Today, dry levelling is carried out and terrace surfaces can account for 5-10 ha. We try to work with water depth not exceeding 10 cm instead of the traditional water heights which were 10-20 cm, sometimes even 30 cm (Pereira et al., 1986). The total water needs for irrigation of a rice crop Portugal varies between 10,000 and 30,000 m^{3}ha^{-1}, according to the type of soil and the impact of rodent and crayfish attacks (Silva, 1969; Pereira, 1989).

❑ The other feature to be considered is related to rainfall at the end of cultivation and the humidity of the air during and after panicle differentiation. Concerning the pathology of the crop, a relationship may be established between these two parameters and the incidence and severity of some diseases that affect the panicle.

After all, in the same rice growing areas, we can find some farmers cultivating excellent rice fields and others not being able to do the same. It must be remembered that there are different structural and technical factors determining rice production and profits in Portugal. At the moment, among the most important, we have to take into account the availability of water (in terms of quantity and quality), production structure and cultivation techniques, crop nutrition, choice of varieties, weeds management and pests control. We must not forget the need to create for the R&D sector structures and even rural infrastructures capable of transferring to farmers the expertise acquired and results of experiments carried out.

1. Production structure

In Portugal, two types of rice growers can be found: i) specialized farmers cultivating some scores of hectares with modern means and conditions of production, ii) small producers (seldom average producers), specialized or not, cultivating just a few hectares (or even less than one hectare) more reluctant to adopt technological innovations in the field production. Thus, beside the wonderful rice fields all over the country, we still can find small and poorly managed terraces.

For Portuguese rice growing to become competitive and for all rice growers to be able to benefit from this exciting and lucrative activity, we have, first of all, to rethink the land structure of the rice producing areas, in particular in the Mondego Valley. Furthermore, we must bear in mind that production factors costs are still higher in Portugal than in other EU countries.

2. Cultivation techniques

Concerning cultivation techniques used in Portuguese rice fields, some farmers are taking the lead in their own production areas (or even all over the country) and are recognized as being as technically advanced and at the same level as their counterparts in other countries. They often visit the main rice growing regions in France, Italy and Spain and are always kept aware of what is happening there.

At present, there seems to be much concern about using large terraces in which the useful surface can reach some 10 ha. For levelling, laser technology and heavy machines are largely used.

Sowing directly takes place on flooded (by aircraft or by hand) or dry (with sower) terraces. For some years now, some rice growers have shown their preference for dry sowing so that they can apply at the same time a pre-emergency herbicide. However, with the increase in the terrace surfaces some have returned to sowing after submersion because they have observed that the time necessary for flooding the terrace is too excessive to obtain an homogeneous germination.

3. Crop nutrition

In Portugal, mineral fertilizers are always used in rice fields. According to studies carried out, there invariably seems to be a strong response to nitrogen while often the crop hardly responds to phosphorous and potassium improvements.

While potassium and phosphorous are applied at the beginning of cultivation by incorporation in the soil, the necessary nitrogen applications are usually split into 2 to 3 supplies.

In soils where the level of organic matter is high and percolation is low, a very common situation in some of the Mondego areas, the fractionation of nitrogen is less critical.

When percolation is high, nitrogen should be applied in three supplies. One (of about one third) by burying and two by covering at the time of active tillering and at panicle differentiation.

As to how efficient is the use of nitrogen in Portuguese rice fields, experiments have shown differences between the efficiency coefficients and utilization according to the producing region, soil type and the year considered. For production usually achieved in the country, nitrogen needs can vary beteen 80 and 150 $kg.ha^{-1}$ of N, with a utilization coefficient less than 50% which can however range between 30% and 80% (Fernandes, personal communication).

4. Varieties

Since the very beginning of rice growing in Portugal, the varieties mostly used have always been some of the best popular varieties in Italy. In the 1940s, among more than 20 varieties which were sowed at that time (INE, 1945), "Chinês" and "Allorio" proved to be the most important with a contribution of almost 85% of the sowing done. In the 1950s and early 1960s, "Chinês" continued to be the most widely cultivated variety in Portugal. The second variety adopted by the country was "Ponta Rubra", a variety which was selected here from the "Agostano" variety (Vasconcelos, 1963; INE, 1965).

Later on, some other varieties were introduced, among which "Precoce 6", "Stirp 136", "Valetejo", "Balilla" and "Ballila Grana Grossa" were the most important. In the early 1970s, the variety "Stirp 136" was the most widely cultivated, followed by "Ballila Grana Grossa", "Rinaldo Bersani", "Ballila" and "Ribe" (INE, 1975). In the 1970s and 1980s, other varieties became widespread and some of them are still cultivated today. At the moment, the most important ones are "Koral" "Lido", "Onda", "Prits", "Ringo", "Strella" and "Thaibonnet". More recently two other varieties, "Ariete" and "Drago", were introduced. The first one was well accepted by rice growers and last year it was very successful in the Mondego valley.

What have so far been the criteria for choosing rice varieties in Portugal? First of all, to satisfy both producers and industrialists, and then consumers.

But for producers four aspects are always taken into consideration when choosing the variety: adaptability, productivity, resistance to diseases and acceptability by industry. When we talk to them we see that they are very careful about the susceptibility of some varieties to parasites.

So far our rice growers have not become very much aware about the environmental problems and this explains why no concern has been shown for the use of more efficient varieties in response to nitrogen fertilizers. For some time now, there is a clear trend to replace the varieties of the short to medium grain type by varieties of the long grain type.

5. Weed control

The flora of the adventitious rice plants in Portugal resemble those found in other rice producing regions in the Community, except for some exotic species which have not yet been mentioned (Vasconcelos and Luzes, 1990). So the herbicides available on the Portuguese market are almost the same as those in other EU countries.

At the moment almost all the major rice weeds in our country are grasses. Given the efficiency of the herbicides used, the red rice (=*Oryza sativa* L.) is undoubtedly the adventitious plant which poses more problems, followed by *Leersia oryzoides* (L.) Sw., which is spreading fast.

When efficient herbicidal treatments fail, either because terraces have been unperfectly prepared, or a poor application of the product, or improper control of water after treatment or even the action of temperatures having lowered after application, strong infestations are chiefly caused by some other adventitious plants. Species most frequently met are of the genus *Echinochloa*, especially *E. crus-galli* (L.) Beauv., which are the most common weeds in our rice fields. Major infestations caused by *P. paspalodes* (Michx) Scribner and by *Cyperaceous* and *Alismataceous* are less frequent.

In order to be able to better control weeds in Portugal, rice growers usually use two treatments. They seldom need to do more than two treatments. Among the herbicides used, the molinate is still the most common. In the more traditional patterns of application, it is used in extreme cases (for treatments before or during sowing or after sowing) or in conjunction with some other substances or active ingredients (usually bensulphuron-methly). Soon another molecule will be found, dimepeperate, which will be an alternative to molinate for treatment before or during sowing.

When a second treatment is necessary, a lot of substances are available. Often technical advisors choose the molecules according to the weeds found and their interest.

To control red rice, besides the use of certified seeds, two strategies have been envisaged: cultural and chemical.

It is recommended that rice fields be cleaned by systematically picking by hand all the red rice plants found. If the farmer starts picking these plants early, he will succeed in keeping his rice field almost free of red rice. Unfortunately, it is frequent to see rice fields with more red rice than the variety cultivated. In this case, the rice grower is left with only one option which is to introduce crop rotation or use chemicals. If crop rotation, with crops such as maize, tomatoes or sunflowers, is possible in some of the rice growing areas of the country, so far there has been no alternative for others which are considered marginal for rice and any other crop.

According to experiments already conducted, the chemical control of red rice has never produced acceptable results (Silva Dias, personal communication). Experiments have been carried out with glyphosate which was applied after the terrace was prepared and the germination of the red rice seeds. Even if this technique is successful, it cannot be used in all the rice fields, except for the south of the country.

6. Invertebrate pests

Among the invertebrate pests causing damage to the rice crop in our country, only three phytophagic insects, *Chilo suppressalis* (Wlk.), *Hydrellia griseola* Fall and rice seed midges (Chironomidae family), and the Louisiana crayfish, *Procambarus clarkii* Girard, can have a major impact.

The attacks by *C. suppressalis* occur either on young rice plants undergoing active tillering or on plants in the process of panicle differentiation. The most visible symptom is that of the “white heads”. Usually farmers undertake no treatment against this stem borer and the damage is sometimes heavy. When the symptoms is serious and widespread early in the season, one or two treatments are recommended with systemic insecticides.

As regards *H. griseola*, the attacks have been huge for some years now and it is believed that the imbalances that occured after insecticide treatments against the Louisiana crayfish have greatly contributed to this situation. Between 1989 and 1991, the losses caused by this leaf-eater made it necessary to resow some rice fields and to treat them widely in some areas. In the last three years its importance has greatly diminished.

For Portuguese rice growers, the Louisiana crayfish is (still) a danger. Yet, despite its polytrophic behavior, direct damage to rice plants is never seen since its food regime mainly consists in detritus. Nevertheless, its activity in the rice field (as well as in lagoons) has become formidable since the water losses seen through the galleries it digs can prevent the flooding of fields, chiefly when the population is high. It was introduced in Spain in 1973 and in 1974 (Badajoz and Guadalquivir, respectively) (Rubio and Sanchez, 1983) and found in Portugal in 1979 in the Caia river (Ramos and Pereira, 1981). Since then, it has slowly spread and is found today in almost every river of the Center and South of the country and in all our rice fields.

On the outset, when our rice growers were faced with this pest, which posed a new problem, at times dramatic, they were forced to use chemicals with insecticides often without any technical or official supervision or guidance. The damage was more serious between 1988 and 1991 and in these last years there was no need to carry out a large scale treatment.

Considering the size of the crayfish market in Europe, Portuguese rice growers will have to rethink their strategy of fighting it and begin to make a business out of it, as is already the case in Spain (Holdish, 1993).

II – Rice diseases in Portugal

1. Parasitic diseases

The beginning of studies on rice diseases in Portugal dates back to the nineteenth century. Until then, only “brança” (symptomatology associated to the poor formation of grains) was known.

The first pathogens of this crop to be found in our country were reported by Prof. Veríssimo Almeida, one of the most eminent mycologists of all times in Portugal. He recorded in 1890 *Sclerotium oryzae* Catt. and later in 1899 *Pyricularia oryzae* Cav. (=*P. grisea* Sacc.). After that, some other pathogens were found and pathogens found today in our rice fields are the following:

Table 1. Rice diseases in Portugal and causal organisms

Disease name	Causal agent	Reference
Blast	*Pyricularia grisea* Sacc. teleomorph = *Magnaporthe grisea* (Hebert) Barr	Almeida, 1899
Stem rot	*Sclerotium oryzae* Catt. teleomorph = *Magnaporthe salvinii* (Catt.) Krause & Webster	Almeida, 1890
Brown spot	*Bipolarisoryzae* (Breda de Haan) Shoem. teleomorph = *Cochliobulus myiabeanus* (Ito & Kur.) Drechsler ex Dastur	Rodrigues, 1949
Bakanae disease and foot rot	*Fusarium moniliforme* Sheld. teleomorph = *Gibberella fujikuroi* (Saw.) Wollenw	Rodrigues, 1949
Sheat rot	*Rhizoctonia oryzae-sativae* (Sawada) Mordue teleomorph = *Ceratobasidium oryzae-sativae* Gunnel & Webster	Lima, 1992
	Sclerotium hydrophylum Sacc.	Lima, 1992
Grain discoloration	*Alternaria longissima* Deigton & MacGarvie *Bipolariscynodontis* (Marignoni) Shoem. *Curvularia lunata* (Wakker) Boedijn *Exserohilum monoceras* (Drechsler) Leonardo & Sugs *Fusarium moniliforme* Sheld *Nakateia sigmoidea* (Cav.) Hara *Mycosphaerella oryzae* (Catt). Sacc.	Santos, 1991 Lima & Garrão, 1995 Santos, 1991 Lima & Garrão, 1995 Santos, 1991 Santos, 1991 Costa & Pereira, 1953
Root nematode	*Hirschmanniella oryzae* (Breda de Haan) Luc & Godoy	Reis, 1990
Rayures bactériennes	*Pseudomonas avenae* Manns	Shakya et al., 1985

a] Blast

Blast is constantly present in our rice fields. However, its presence varies from year to year depending on the climatic and crop conditions.

According to the available information, when the disease was first recorded at the beginning of the century, it was not important since it was only found in small foci. Later on, at the end of the 1940s and early 1950s, it took on much importance after having caused serious damage in many rice fields. At that time attempts were made to control it through chemical treatments. However, it was kept in check after the most sensitive varieties were abandoned. But, since then, blast became the most widely known rice disease in Portugal and for rice growers it was the cause of major losses.

Yet, after the major attacks of the 1950s, blast was observed every year yet without causing any severe damage. During this period it was seen in some rice fields in the Mondego and Sado basin.

More recently, since 1989, the blast disease incidence and severity have increased. Since the month of July, attacks in some areas may be of major consequence.

Very often one sees focus in which leaves are attacked leading to the death of plants. Seldom do these attacks affect all the plants in a field. Usually these sources of infection appear as focus where plants are more developed or shaded by trees close to terraces.

Despite this, the most severe damage was the result of the attacks in the upper part of the culm and the panicles (neck blast). These infections are responsible for the damage which can range from partial to total sterility of the panicle.

As for culm infection, above or at the level of the node of the flag, leaf blade lesions can be observed which result in the drying up of the panicle. On the other hand, when the attacks on the rachis occur very late at the grain filling stage, the specific weight of the grain lowers with the subsequent reduction of the industrial yield.

These symptoms are very common in the Mondego Valley where, in some places, hundreds of hectares are affected by the neck disease or infected rachis in September.

Unfortunately, there exist no data quantifying the losses caused by the blast disease in Portugal. But, according to knowledge available now, it may be said that in the main producing areas there are risks of severe attacks, in the Mondego Valley and in some places of the water basin of the Sado.

As for the conditions which can influence the severity of blast in our country, one observes:

❏ **The environmental factors**. Humidity and temperatures are the two major factors likely to play a determining role on blast development in Portuguese rice fields.

The climate is of the Mediterranean type with an Atlantic influence which is noticeable in the main rice growing areas. The vegetative cycle of rice coincides with the hot and dry period of the year. Yet in the areas where the disease is more serious, lasting wetness due to mist is often enough to allow the plant's infection.

Temperature is a critical factor when there is a major lowering of the temperature after the panicle differentiation or when sowing takes place late.

❏ **The susceptibility of the variety**. Although we have already found infections of *P. grisea* on almost all the varieties of rice grown in Portugal, the most severe attacks, either on leaves or panicles, were found on “Onda” and more recently on “Strella”, “Koral” and “Thaibonnet”.

Last year, in the Mondego Valley, important or severe attacks on panicles were also observed on the “Ariete” variety.

In a study we carried out on inoculation concerning 10 rice varieties which are now being cultivated (“Ariete”, “Drago”, “Koral”, “Lido”, “Onda”, “Pritz”, “Regina”, “Ringo”, “Strella” and “Thaibonnet”) with Portuguese strains of *P. grisea*, we found that 8 varieties were sensitive to the disease, “Drago” and “Regina” being the only resistant ones.

The varieties usually obtained from Portuguese rice improvement programs, such as “Regina”, are often very resistant to blast but unfortunately they are very sensitive to stem rot.

❏ **Late sowing**. In the case of late sowing, the final phase of the crop cycle coincides with favourable conditions for disease development. In such a situation, besides the temperature, humidity in particular is favourable to the disease.

❏ **Rate and fractionation of the nitrogen fertilization**. As stated earlier, for the national production nitrogen needs can range between 80 and 150 $kg.ha^{-1}$ of N. In areas where blast is not widespread rice growers often exceed these doses without almost any risk of seeing their production lost by a severe attack by the disease. Such is not the case in regions where the attack could be more severe. Although there is an increase in yield when the quantity of nitrogen foreseen is fractionated, a late supply leads to the panicle's strong susceptibility to the disease. In the Mondego Valley, we sometimes found rice fields with such strong blast attacks that the plants look as if they were burnt. This situation can be compared to a late topdress supply of nitrogen, mainly of urea, when climate conditions are favourable to disease development.

- ❑ **Presence of red rice in the rice field?** The first symptoms of blast are often found on red rice plants. Furthermore, sometimes the infection remains on these plants and does not succeed in affecting the cultivated variety. For varieties we have studied since the beginning on the crop, “Thaibonnet”, “Ariete” and more recently “Drago”, a first year infection is very rare or even non-existent, in spite of the red rice infection. Does the red rice play an important role in the epidemiological development of blast in Portugal? Studies have not yet been carried out to suggest any reply.

- ❑ **Control.** Besides general measures, such as early sowing, choosing less sensitive varieties in areas where the attack is more severe and rational fertilization, the current blast control in Portugal is based on 2 strategies: seed treatment and chemical combat at the field.

  Usually our rice growers are concerned about treating their seeds. They use a mixture of a systemic fungicide (often benomil) with a dithiocarbamate (mancozeb and thiram).

  For rice seeds subjected to certification, for a period of 21 years (1965-85) it has been shown that the percentage of samples with *P. grisea* has varied from year to year between 3% and more than 37%. For these samples 2.5% had more than 5% of infected seeds. The level of 5% of infected seeds was recommended as a limit to permit certification (Santos, 1989).

  In the last few years, some rice growers have begun to use chemicals as field sprays in order to control neck rot. Since there have been no warning services to collect and provide information on the possible outbreak of an epidemy; rice growers in the areas climatically favourable to the disease make preventive treatment just before heading or after the occurrence of the focus of infection. Often technicians from companies selling these chemicals recommend this treatment. At the moment, tricyclazol is the only officially accepted fungicide to be used in field sprays. According to knowledge held on the disease, the potential risk justifies one or two preventive treatments against neck blast in some areas of the Mondego Valley and the Sado basin and also in some rice fields in Elvas (Guadiana).

b] Stem rot

The rotting of the rice culm caused by *Sclerotium oryzae* Catt. has been known in Portugal since the end of the last century. It is currently found in all our rice fields and in certain regions it is much more widespread than blast. Our surveys in the Mondego, Tagus and Sado rivers in 1990 and 1991 (Lima, 1992), led us to conclude that damages could be severe in all the regions. Stem rot is undoubtedly the disease most easily recognized by our rice growers. In the Tagus Valley it is on the top list of diseases which can endanger the yield.

In Portuguese rice fields, although the first symptoms due to the rotting of the stalk are seen at the stage of active tillering (Lima, 1992), all the levels of severity of the disease can be observed. In the less serious attacks, infections stay latent and the plants reach the stage of panicle differentiation without showing visible symptoms. Sometimes even in maturation one notices the disease quite simply because in the culm sclerotia can be seen. However, there are other signs of the attack which determine more visible repercussions on the appearance of the rice field.

In the case of more serious attacks, the leaves become yellow, dry up and turn brown. Upon maturity, if these plants have not succumbed before, the culms bear the panicles with numerous aborted flowers or poorly formed grains. If we try to detach the culms, we can see that they break very easily at the level of the most darkened area of the culm. In such a situation the loss is very significant. Sometimes the yields are so low that the rice growers choose not to harvest.

Still, the most frequent sign of the disease results from an infection which remains latent up to the phase prior to heading, then taking on a epidemiological character. During maturation the infected culms may lodge or break as a result of the weight of the grain or the action of the wind. When we look at the culms we find that the lower inner nodes are darkened, disorganized, and inside the sheaths and the stubble we can see the typical sclerotia of the fungus. Sometimes in these culms themselves only the epidermis resisted to decomposition. These late infections cause an action which affects both the quantity and quality of yield.

However, no epidemiological study on this disease has been done in our country and there is no accurate knowledge about the extent of losses. Besides the most severe attacks which can destroy the entire production, the rice growers often argue that the losses are negligible, of up to 25%.

According to the experience we have about the disease, we can indicate the following conditions as the ones which can most often determine the disease severity:

❑ **Susceptibility of the variety**. All the varieties cultivated in our country are susceptible to stem rot (Lima, 1992). However, the most severe attacks we have always ascertained were on the variety “Onda” and at times on “Strella”. The susceptibility of these varieties, especially for “Onda”, is recognized by our rice growers to such an extent that most of them have ceased to cultivate this variety, although industrialists prefer these varieties. Sometimes severe attacks are also seen on “Prits”, “Ribe”, “Riva”, “Thaibonnet” and “Venaria”. Last year we found a severe infection of stem rot in a “Thaibonnet” rice field, alongside another unaffected rice field of the same variety, unless the plants had sclerotia but did not show visible symptoms. It was not possible to establish a link between this attack and any crop technique.

❑ **The quality of irrigation water and how frequently it is renewed**. Often rice growers do not have the available irrigation water allowing appropriate water renewal or do not have good quality water. Under these conditions, they are compelled to leave the same water in the rice field as long as possible. When this water becomes stagnant, a sharp increase of the disease is observed. Or, worse, they can be forced to reutilize this water to irrigate a rice field.

❑ **Nitrogen manuring**. Although in our country we cannot establish a correlation between the impact of the stem rot and the quantity of nitrogen supplied to the crop and due the fact that we cannot give details on all the factors which may contribute to the severity of the disease, it is often seen that it became more serious in rice fields where the level of nitrogen was the highest.

❑ **Control.** Despite the importance of the disease, the control measures taken so far are mainly of a general character. Thus, rice growers are recommended:

1) to destroy the stubble by burning, after harvest, when the field was severely attacked.
2) to prevent water stagnation in the rice field and to use proper water to reflood.
3) to adopt rational fertilization using the minimum amount of nitrogen required to allow the optimization of production and using potassium and phosphorus fertilizers as well.

c] Brown spot

This is a disease found in all the rice growing regions in the country which affects leaves and grains without apparently posing any economic problem.

The symptoms on the leaves are more frequent at the end of the cycle and in the rice fields where the soil conditions are not the most favourable to the development of the plant. However, noticeable attacks have also been observed in some well treated and fertilized rice fields.

During the surveys carried out in the past few years in our rice fields, we have noticed the most spectacular attacks on the varieties “Veneria” (in the Palmela region) and “Koral” (in the Mondego valley). Nonetheless, in a pathogenicity study concerning some strains of fungi of the genera *Bipolaris* and *Exserohilum* obtained from rice in our country, we have not observed any differences in susceptibility among these varieties and other tested ones (“Lido”, “Maratelli”, “Ringo” and “Strella”) (Lima and Garrão, 1995).

The attacks on the grains are not important and often its spores are found on the glumes, associated to the structures of other fungi.

❑ **Control.** No means of control have been specifically recommended against this disease. Nevertheless, knowing that the parasite can kill the seedling from the infected seeds, rice growers are told to treat the seeds. But the frequency of seed infection in our country is not very serious. According to studies carried out on rice seeds which were subject to certification, the percentage of samples with *B. oryzae* is relatively low and very seldom do we see samples with more than 5% of infected seeds (Santos, 1989).

d] Other parasitic diseases

The other diseases or parasites reported in the above table (Table I) are not important. So it is not worthwhile discussing them. Besides, no means of control have yet been developed to combat them.

We must however mention that some other plant pathology situations found in our rice fields can be caused by parasites. We have to carry out etiological studies on the symptomatologies resembling the following diseases:

"Giallume"

This is a major disease in Italy known since 1955 (Baldacci et al., 1970). It is caused by a strain of the barley yellow dwarf virus. The most noticeable symptoms are yellowing and a slight rolling over of the leaves and dwarfing of the plants. In our country these symptoms are found in small isolated foci, hardly exceeding 2 to 3 meters diameter. At the moment it is not yet important.

Bacterial sheath rot

Bacterial infections in which symptoms produced are brown lesions on sheaths and discoloration of grains can be caused by 2 bacteria of the genus *Pseudomonas, P. fuscovaginae* Miyajima, Tanii and Akita and *P. syringae* pv. *syringae* van Hall (Agarwal et al., 1994). Symptoms similar to that described for such bacteria are found in our rice fields and in attempts to isolate the pathogen associated to them we have consistently obtained colonies of a bacterium of this genus. We have identified it as *P. syringae* pv. *syringae* but still we have not succeeded in showing it pathogenicity. The importance of the disease has not yet been determined.

2. Physiological diseases

Among the physiological rice diseases in Portugal the most important are "Brança" and, quite recently, "Akiochi" (autumn decline).

a] "Brança"

"Brança" has been known in our rice fields for very long time. It is a syndrome (always related to sterility) rather than a precise disease. Consequently, under this designation we see different symptoms and surely distinct causes responsible for them. By discussing this syndrome, Silva (1958) acknowledges that "Brança" according to the traditional concept in our country can be of parasitic, physiological or genetic origin.

Yet, "brança" of physiological origin is more usual and important. The plants affected by it show a normal development, but with different degrees of floral or paniculate anomalies which in the more serious situations lead to the deformation of the entire panicle. More frequently, there is simply floral abortion which becomes more visible during maturation when the panicles with empty spikelets turned upright while those filled fell under the weight of the grains.

In some aspects, our "Brança" is similar to the straighthead disease reported from other countries.

The most important factors commonly associated to the physiological "brança" in our country are unfavourable climate conditions during the flowering stage (temperature, wind, mist), soil conditions, unbalanced fertilization (especially with excess nitrogen) and also lack of copper (Graça, 1942; Rodrigues, 1949; Cunha and Baptista, 1958; Lima, 1962; Ricardo and Cunha, 1968).

According to the studies conducted about this disease, it may be concluded that when "brança" is caused by lack of copper the impact is not directly correlated to the quantity of copper existing in the land but to its availability (Cunha and Baptista, 1958; Ricardo and Cunha, 1968). Thus, they have differentiated "brança" which occurs in poor lands because of lack of copper and tends to be more and more serious year after year, and the "brança" of the rich lands which occurs hardly 2 or 3 years after submersion.

They have further shown that a supply of 75 to 100 $kg.ha^{-1}$ of copper sulphate controls “brança” caused by lack of copper.

In the last decade this disease became less frequent. The varieties now utilized are less sensible to the physiological factors inducing floral anomalies.

b] Akiochi (autumn decline)

This is a disease of premature ageing in plants. It is observed, often in irregular patches on a field, through different symptoms of which the most visible are: normal growth in the early stages and reduction in plant growth after active tillering; drying of the edge and top of leaves; tiller without and with panicles; reduction in the number of spikelets and the weight of the grains in the panicles of the plants infected. The root system of the plants is poorly developed and blackened.

These symptoms are found in our rice fields where crop conditions are poor, notably as regards the frequency with which water is renewed.

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