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Review Article

Analytical review of the study of the fungal flora of rice: case of Sigatoka (*Sphaerulina oryzina*)

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Abstract: The important development of cereal crops, of which rice has seen, at the same time, many infectious diseases causing a dramatic fall in yields. Very few studies have been conducted on cercosporiosis in Benin as a minor ailment. But nowadays it appears more and more in the rice fields and it is important to take an interest in this pathology in order to be able to control it. The purpose of this review is to summarize the work done on rice leaf spot in order to define research perspectives for a better control of this pathology by allowing the producers to be able to recognize the symptoms of Sigatoka and to adopt appropriate methods of fight. This review is based on documentation focused on the relevance of articles. The results show that rice faces many abiotic and biotic constraints. Among the biotic constraints we have diseases due to bacteria, viruses, nematodes, fungi.

Among the best known and studied fungal diseases are blast, helminthosporiosis, leaf scald, faux charcoal. Cercosporiosis considered to be a minor ailment is under-researched and is generating a great deal of research for the study of this pathology. This analytical review shows that a research perspective focused on the study of Sigatoka in rice could boost rice production in Benin and ensure better productivity in the coming years, to limit its dependence on rice elsewhere.

Keywords: Rice, Oryza sativa, Pathogen, Fungal, Cercospora, *Sphaerulina oryzin*

INTRODUCTION

Rice is the main source of food for nearly 3.5 billion people, more than half of the world's population[1]. It is a staple food that provides 27% of the energy intake of people in Third World countries and 24% of their dietary protein[2]. This cereal is produced and consumed in 38 countries in Sub-Saharan Africa where annual growth in demand is estimated at about 6% [1]. Two rice species are mainly cultivated in Africa: Oryza sativa L. (Asian rice) and Oryza glaberrima Steud. (African rice) [3,4].In West and Central Africa, demand for rice is growing at around 6% per year, faster than anywhere else in the world, due to high population growth, changes in the diets of populations and regular deficits of traditional grains such as: sorghum, millet and maize. To meet this growing demand, states with a deficit in production resort to import, as generally low local production is insufficient[5]. This leads to dependence of African countries vis-à-vis the outside world; which does not guarantee the food security of these countries.

The Africa Rice Center (Africa Rice) has estimated that, given the trends since 2008, rice production and consumption will grow exponentially by 2020 [6]. Faced with this situation, efforts are being made by research to develop varieties with high yield potential. The rice sector in Africa is one of the key sectors for food security that still faces real problems for its development; in particular, the lack of knowledge about the quality of African rice varieties (Oryza glaberrima) and their lack of adoption due to suspicions about their nutritional value[7]. The rapid establishment and uptake of new rice varieties through advances in the breeding process has resulted in the loss of traditional and local varieties [8.] However, local varieties provide a large reservoir of potential resistance that is useful for plant breeding programs[9, 10.The] pathology of cultivated plants is known and the impact of these pathologies on seeds can help us to improve their productivities[11]. Rice diseases in West Africa have been categorized as major diseases, secondary conditions and minor diseases[12]. Our study investigates the Sigatoka disease of rice caused by sphaerulina oryzina as a minor ailment [13]. We will be interested in this disease to understand how it develops and why it is considered minor affection. This analytical review will allow us to know the different ecotypes of rice, the agro-morphological characteristics of rice, the different biotic and abiotic constraints to rice production and a summary of the activations conducted on Sigatoka and other fungal diseases of rice.

METHODOLOGY

The writing of this review was the subject of a bibliographic search in several databases namely: Thèse.fr, Sciencedirect, Online memory, Agora, Hal. Open Archives, also in the Africa Rice Center article archive (AfricaRice). In total, about one hundred scientific articles published in indexed and / or internationally impacted journals have been exploited. Relevant rice information from technical reports and scientific papers was also collected.

RESULTS

Main areas of rice production: The major rice producing countries are Asian countries including Bangladesh, India, Pakistan, Thailand, Vietnam, mainland China and Indonesia. They are also the main consumers[14]. The main areas of intense rice activity in Africa are its West and East zones, which account for nearly 95% of rice production[15]. In Africa, erratic rains have worsened production prospects in Madagascar and Tanzania, while in Egypt, production may also decline due to increased land use for cotton. However, in the absence of a major setback, continued efforts to reduce import dependency could lead to further growth in West Africa, thereby keeping production across the continent at a high level. Close to the excellent harvest of 2016 [14].

Rice production in West Africa: Rice in Côte d'Ivoire accounts for 65% of cereal production, maize 20%, millet and sorghum each 2% and fonio less than 1%. According to the USDA, [16] in recent years lack of funding, insufficient seed supply, limited capacity of rice mills and low market prices have deterred some farmers from growing rice. The USDA points out that in many West African countries imported rice is generally cheaper than domestic rice. Indeed, rice imports from some countries may continue to increase. This is especially true in countries not covered by the USDA review, such as Nigeria, given the rapid growth in consumer demand[16]. According to CILSS, in the last five years, the price of locally produced rice is on average 10% more expensive than imported rice. The major rice producing countries in West Africa according to the FAO[14] are shown in **Table 1.**

Table 1: Rice production in West Africa [14]

Country	productions (1000 tonnes)			Imports (1000 tonnes)			Consumption (1000 tonnes)		
	2015/16	**2016/17**	**2017/18**	**2015/16**	**2016/17**	**2017/18**	**2015/16**	**2016/17**	**2017/18**
Burkina Faso	211	250	260	350	350	375	575	600	625
Cote d'Ivoire	1 836	1 335	1 690	1 250	1 400	1 450	2 800	2 900	3 000
Gambie	45	32	36	155	165	170	195	200	205
Guinée Bissau	102	111	120	140	140	140	248	252	257
Guinée	1 351	1 435	1 452	565	470	570	1 770	1 815	1 864
Mali	1 515	1 800	1 800	170	50	50	1 685	1 800	1 925
Niger	60	72	75	300	300	310	360	382	383
Sénégal	624	642	680	1 000	1 000	1 100	1 600	1 675	1 725
Togo	77	89	94	150	150	150	227	233	239
Total	**5 821**	**5 766**	**6 227**	**4 080**	**4 125**	**4 315**	**9 460**	**9 857**	**10 223**

Requirements for rice production, main rice ecologies: One of the most original characteristics of rice is its ability to be cultivated under a wide variety of environmental conditions, especially from the point of view of its water supply: rainfed culture fed solely by rainwater, floating culture in a water blade of up to several meters, all intermediaries are possible. The cultivation of mangrove rice and floating rice occupies very small areas[17]. Most rice production ecologies have similarities such as parasite pressure, decreased soil fertility, and increased weed pressure[18]. A nomenclature adapted to Africa is that of l'ADRAO[19] which separates two basic types: submerged rice cultivation, rice-growing without submersion. We distinguish in Africa:

- Mangrove rice cultivation: This type of rice cultivation represents about 10% of rice growing areas in Africa (Guinea-Bissau, Sierra Leone, The Gambia, Nigeria and Senegal ...) **(Photo 4).**
- Freshwater rice farming: Depending on the degree of control of the water that is reached, it is possible to differentiate between rice growing without water control (22.5% of rice areas in Africa) and rice growing with water control (5% of rice areas in Africa) **(Photo 3)**
- Strict rained rice cultivation: Represents 60% of rice areas in Africa **(Photo 1)**
- Paddy rice cultivation: Paddy rice cultivation is not widespread in Africa with only 2.5% of surface area **(Photo 2**).

Photo 1: Strict tropical rice growing
Source : www.invasive.org

Photo 2: Rice tablecloth
Source : www.invasive.org

Photo 3: Freshwater rice growing
Source: www.invasive.org

Photo 4: Mangrove rice growing
Source: www.invasive.org

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Agromorphological Characteristics of Rice: Rice (Oryza spp.) Is a branching plant of Spermaphytes, of the class Monocotyledonous and of the order Cyperales belonging to the family Poaceae and genus Oryza. The genus Oryza is part of the subfamily Panicoideae and the Oryzeae tribe[3]. The genus Oryza comprises about twenty species of which only two are cultivated: Oryzae sativa L. (genome AA, 2n = 24) with world distribution and Oryza glaberrina Steud (genome AA, 2n = 24) cantoned in West Africa [20].

Oryzae sativa comprises two main types, the indica type and the japonica type: Oryzae sativa is the most widely grown rice species anywhere else in the world[21]. The Asian form of O. rufipogon would be O's direct ancestor. sativa while O. breviligulata would be that of O. glaberrirna [22]. The species Oryza sativa was introduced to West Africa by the Portuguese in the 1500s [23]. In 0. sativa, we recognize three major morphological types. The indica type is characterized by strong tillering, narrow leaves, fine roots and a fine grain. Varieties of this type are those of aquatic culture in low-altitude tropical regions (less than 1,200 meters). The japonica type is characterized by medium tillering, narrow leaves, fine roots and a rounded grain. This type is that of aquatic cultivation varieties in temperate regions and in high altitude tropical regions. And the type javanica is defined by a weak tillering, broad leaves, thick and deep roots and a long and wide grain. These are rainfed varieties in tropical regions and varieties of aquatic culture in the United States [24].

Rice is an annual herbaceous plant, self-pollinating, more or less pubescent with upright round stubble (except for floating varieties), arranged in tufts covered with flat sessile leaves in the shape of a blade and bearing at the end of panicle-shaped inflorescences[4,15]. A rice plant of any species includes a root system, stem, leaves and inflorescences [19] **(Figure 1**).

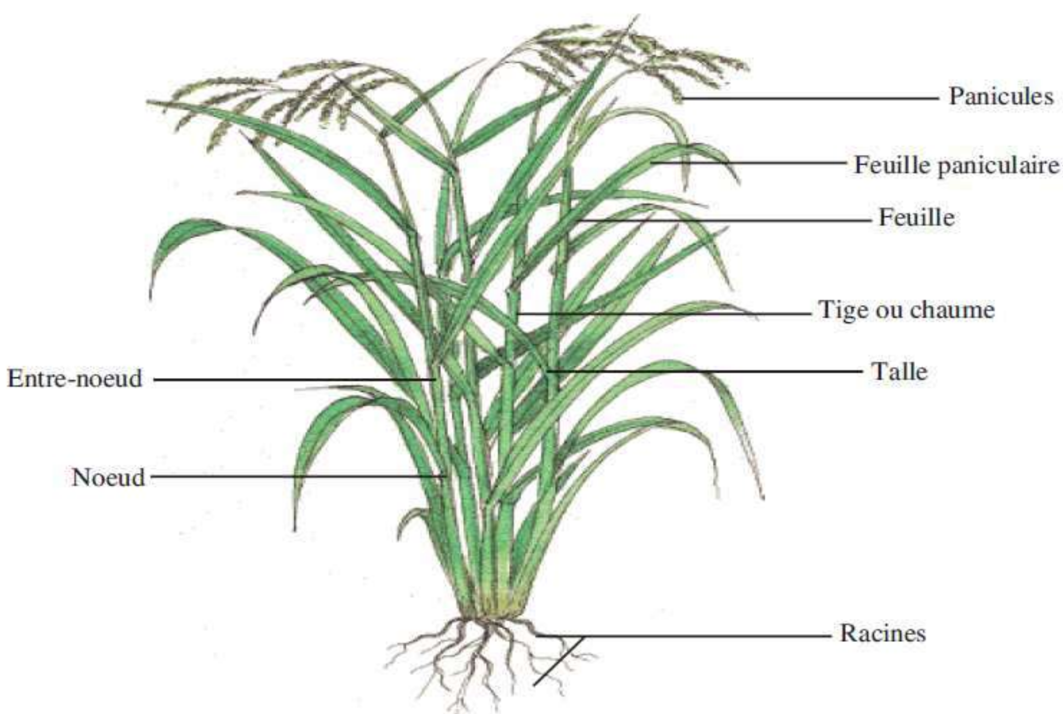

Figure 1: The rice plant[15]

Nutritional value and importance of rice in the human diet: Rice is the world's leading food grain in terms of production and is the staple food for a population of more than three billion people. Equates to more than half of the world's population[25]. The annual consumption of rice per capita can be very important in the major consumer countries of Asia or Africa. In fact, in the Philippines, Madagascar or Guinea, per capita consumption exceeds 100 kg / year. In addition to being a source of food for about 50% of the world's population, rice is the main source of protein for more than 2.5 billion people in developing countries[26, 27]. It is distinguished from other cereals by its high content of glutelins (soluble in diluted bases) and low in prolamins (soluble in alcoholic solutions) [21, 28]. In terms of nutrition and in general, rice has a wide range of nutrients **(Table 2)** In West Africa and outside Nigeria, regional rice consumption ranks first with 27% of all cereals consumed ·The exploitation of data from surveys conducted by WFP (World Food Program) and its partners in Benin (2009), Liberia, Guinea- Bissau and Senegal (2010) makes it possible to situate the place of rice in the family food security of these countries. Contrary to what one might think, rice does not seem to be a food specifically consumed by urban households. The contribution of rice to overall food consumption is particularly high for food-insecure households, particularly in urban areas[29]

Table 2: Nutrient Content Assessed in 100g Cooked Rice[30]

Name of constituents (units)		Mean grades
Energy (Kcal)		130
Water (g)		70,4
Nutrients	Protéines (g)	2,8
	Glucides (g)	28,8
	Sucres (g)	0,11
	Amidon (g)	28,7
	Lipides (g)	0,37
Fatty acids	Saturés (g)	0,07
	Monoinsaturés (g)	0,07
	Polyinsaturés (g)	0,09
Dietary fiber (g)		0,9
Minerals and trace elements	Sodium (mg)	2
	Magnesium (mg)	9
	Phosphorus (mg)	55
	Potassium (mg)	56
	Calcium (mg)	19
	Manganese (mg)	0,35
	Selenium (µg)	8,2
Metals	Total Iron Metals (mg)	0,24
	Copper (mg)	0,07
	Zinc (mg)	0,37
Iodine (µg)		5
Retinol (µg)		0
Beta carotene (µg)		0
Vitamins	B1 or Thiamine (mg)	0,07
	B2 or Riboflavin (mg)	0,01
	B3 or PP or Niacin (mg)	2,31
	B5 or Pantothenic acid (mg)	0,32

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	B6 or Pyridoxine (mg)	0,15
	B9 or total folates (µg)	4
	B12 or Cobalamines (µg)	0
	C (mg)	0
	D (µg)	0
E vitamin activity (= alpha-tocopherol) (mg)		0

Socio-economic importance of rice: Recent FAO data reveal that, unlike in 2016 when international rice prices were at their lowest level, the first few months of 2017 have already been characterized by rising prices, especially for farmers' fragrant varieties. This observation comes under the FAO Rice Price Index (2002-2004 = 100), which averaged 198 points in mid-April, up 6% from December 2016 [14]. At the regional level, rice is one of the crops of interest, highly strategic and has considerable potential for profitability across the regional market[31]. Its strategic importance and interest comes not only from the fact that the rice industry employs more than 20 million rural actors and is (directly or indirectly) the livelihood for more than 100 million people[31] , but also due to the fact that the West African region is experiencing a sharp currency drift due to massive rice imports[32]. Much of the rice produced in Africa is self-consumed [33]. A tiny part is marketed on international markets. Despite the numerous production costs, rice in Togo, for example, is the most profitable crop among cultivated cereals[34]. Despite the efforts of West African states and sub-sector subsidies in some countries, such as Senegal, the development of this crop remains linked to the production and trade policies of Asian countries.

Constraints to rice production

Abiotic constraints to rice production: Rice is grown in a wide variety of habitats covering a wide range of altitudes and latitudes. This plant, of aquatic origin, and therefore quite demanding in water compared to other cereals, is especially characterized by a great plasticity vis-à-vis its conditions of water supply [35]. Based on topography and water supply of rice[36]. The main constraints inherent to rice cultivation in lowland rice cultivation are presented in Table 3. Generally, rice O. sativa grows on dry or flooded soils and its average temperature during the growth phase ranges from 20 to 38 ° C. C. Nighttime temperatures below 15 ° C can result in sterility of the spikelet[37]. Temperatures above 21 ° C during flowering are necessary for anthesis and pollination. In rainfed systems, rainfall of at least 750 mm over a period of 3-4 months is required, and unlike the African species, O. sativa is vulnerable to drought[19].

Table 3: Different inherent stresses encountered in the continium plateau_bas-fonds source: www.warda.org

Top of slope	Downhill	Minor bed
Drought	Weeds	Bad control of water
Weed explosion	Water Management	Extreme temperature
Attacks of stem borer insects	N deficiency	N deficiency
Termite attacks	Drought	Salinity, alkalinity / acidic waters
N and P deficiency	Drought toxicity	Bacterial burns of leaves
Soil Erosion and Soil Acidity	Insects	

	Drillers of the stems	
	Yellow panachure of rice	
	African midge	
	Bacterial burns of leaves	

Biotic constraints: Rice generally suffers harder from pests, which include insects, diseases, nematodes, rodents, birds and other animals[13]. Weeds are competitors for nutrients, water and light. For rice, weed competition can be so strong that without effective and timely control the harvest would be completely destroyed. Weeds reduce yields and product quality and harvest efficiency, and they increase disease, insect and other pest problems by serving as hosts[38]. Grasses, sedges and annual broadleaved weeds are the undesirable flora of rice. In order to be successful, rice cultivation requires the use of technologies and cultural practices adapted to the soil and the climate of the region. These include: sustainable cropping systems; soil preparation and handling of seeds and seedlings properly; fertilizer application; cultural and chemical control of weeds, diseases and pests; stress management; use of resistant varieties; and harvesting and post-harvest work done properly. Local varieties play an important role in developing resistance to pests and fungal diseases[39] they have good qualitative characteristics[40].

Weeds: These are undesirable plants that compete with plants that are useful for the essential elements of growth and development, thus causing significant yield losses[19]. They can serve as hosts for diseases and insects. In addition to this, some weeds are sources of inoculum for many rice pathogens. The partial losses due to weeds in the West African region vary from 8 to 15%. Weeds *Scleria tessellata, Panicumrepens, Leersia hexandra, Lipocarpha chinensis, Rottboelia cochinchinensis and Sporobolus pyramidalis are infected with Bipolaris oryzae; Echinochloa colona is infected with Pyricularia oryzae; Pennisetum unisetum and Eleusine indica are both infected with Pyricularia oryzae and Bipolaris oryzae*. They compete with rice for nutrient research in the soil. When their numbers are large, they cause a drop in crop yield [41].

VIRUSES:

Yellow variegated rice: The virus was first identified in 1966 in Kenya. The yellow variegation of rice is caused by RYMV (RiceYellow Mottle Virus). It is in the form of an ultra-microscopic particle of 26 to 30 mm in diameter observable by an electron microscope. The disease takes its name from the yellowing symptoms of the leaves of infected plants. The main symptoms are: stunting, reduction of tillering, foliar variegation by yellowish streaks, panicles sometimes malformed and sterilized[42]. Initial symptoms result in yellowing occurring 10 to 15 days after inoculation, showing a relatively distinct mottling on the juvenile leaves **(photo 5).** For some varieties, the older leaves have an orange tint that can be confused with symptoms of iron toxicity, with the difference that the typical symptoms of RYMV virosis are completely absent in this case [13]. The tillering, perhaps severely affected in case of early attack and within limits, causes the total destruction of the plant. In the field, the infected plants are spotted 3-4 weeks after transplanting and are remarkable for their yellowish appearance. Yellow leaves show speckles or greenish-yellow streaks. [13]. The use of resistant varieties appears to be the most promising way to control RYMV[42].

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Photo 5: Symptoms of yellow variegation of rice [42]

Rice dwarfism: It first appeared on the IRRI[43] farm in 1969 and was transmitted by the brown leafhopper (Nilaparvata lugens). When well developed, symptoms on diseased plants are expressed as severe stunting, excessive tillering and erect growth **(photo 6).** Leaves are short, narrow, erect, pale green or pale yellow and often have many dark brown spots of various shapes that form mottling[13]. They worm themselves with an adequate supply of nitrogen fertilizer. Yield losses due to plant infestation can range from zero to the entire crop. The fight against this disease is the use of resistant varieties

Photo 6: Rice plants with dwarfism Source: www.fao.org

Rice tungro: Nephotettix virescens is the main vector of tungro. Vectors, feeding on the phloems of infected plants, contract the virus and then transmit it to healthy plants as they feed[44]**.** The virus is non-persistent, ready to be transmitted within two hours of being contracted. Tungro induces a significant drop in leaf chlorophyll[45]. The vector multiplies rapidly in the early stages of vegetative growth, migrates long distances and spreads the disease rapidly. Tungro is endemic in areas where crops overlap or where they are continuous. The leaves of the affected plants become orange or red bricks, associated with a chlorosis of newly emerged leaves **(photo 7).** Infested plants are considerably stunted and have a reduced number of tillers[38]. They may not have panicles, or they may emerge from them, do not lie down, and have discolored and strawy spikelets. Out of season, the virus takes refuge in wild rice, stubble and weeds without manifesting itself.

Photo 7: Symptômes du virus tungro du riz [39]

BACTERIOSES

Bacterial wilt: It is caused by Xanthomonas oryzae pv. oryzae, a gram-negative, rod-shaped bacterium belonging to the family Xanthomonadaceae. Its mobility is ensured thanks to a polar flagellum. In cultures on nutritive agar, circular colonies appear continuous, smooth, convex, opaque, first yellow whitish then pale yellow. In cultures on solid media, the colonies have a round, convex, yellow color, due to the production of xanthomonadine pigment, the true characteristic of the causal gene. They are important in the formation of droplets of bacterial exudates from infected leaves and serve as protection against wind-drying and late arrival of rains. The symptoms produced by X.oryzae pv. oryzae are of three types [46]: leaf blight, wilting, and pale yellow yellowing **(photo 8).** Disease control strategies should be based on methods that avoid variability of inoculum sources and that minimize the spread of the disease (bacteria) in the field [46]. Apart from chemical and biochemical methods, there are some cultural practices.

• The judicious use of the normal nitrogen dose and the recommended urea (150 kg / ha). This dosage is reduced by 50 kg / ha when the disease is observed in the field (Dharam,)

• The removal or burning of straw from the attacked plants [47]

• The use of healthy and unharmed seeds.

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Photo 8: Symptoms of bacterial wilt in rice Source**: www.invasive.org**

Insects: Insect pests and pathogens cause financial losses to warehouses, destroying up to 5% of products. Seed storage molds are the main cause of major events of deterioration of stored seeds. They are the cause of decreased germination, discoloration and biochemical change, decay, decay and mycotoxin production[20] Research shows that insect pests that attack stored products cause financial losses to farmers but also huge regional disparities. Since 2009, production has increased in several African countries and storage has become a widespread practice. In a sample of 65 rice warehouses, a survey revealed that for a storage period of between four and six months, the financial losses could reach 2115 F CFA per ton of rice stored in the South against 8,000 F CFA in the South. North[48].

Nematodes: Forty kinds of nematodes are associated with rice worldwide. They are classified into two groups, depending on whether they cause symptoms and damage to the roots or to the aerial parts [45] (photo 9). Indeed the nematode Hirschmanniella oryzae, is widely spread probably in all the rice-growing countries of the world. The genus Aphelenchoides is an ectoparasite of leaves that includes several species primarily attacking ornamental crops and vegetables. The species attacking rice and causing "The White tip disease" has been described in many West and Central African countries[49]. The nematode enters the root through the epidermis, feeds on the parenchymal tissues and multiplies. On the stems and panicles, the nematode is distinguished from "white tips" (Aphelenchoides besseyi, Christie) which present at the time of the phase of elongation of the stem, clearly visible symptoms on the leaves and whose ends give a whitish color and chlorotic over a length of about 5 cm that curl and die[45]. Disease caused by the stem nematode (Ditylenchus angustus, Filipjev) where paniculate leaves, accompanied by mosaic discolorations accompanied by a tension at the base especially when they are still young. The panicles twist and partially sterilize[45]. The damage caused is moderate and the use of some control measures such as the use of Sesbania rostrata Brem, a trap plant or the spreading of an excess of nitrogen fertilizers proved their effectiveness in the Philippines[50]. Likewise, the use of nematocytes has allowed significant gains in yields only that their very high cost makes their acquisition difficult.

Photo 9: Symptoms caused by hirschmaniella oryzae Source: www.invasive.org

The mushrooms

Helminthosporiosis or brown spot disease: The causative agent Drechslera oryzae is also known as Helminthosporium oryzae or Bipolaris oryzae or Cochliobolus miyabeanus and is transmitted by contaminated seeds. It is usually associated with soil problems, deficiencies or release of toxic substances such as hydrogen sulphide. The seeds are the sources of the primary inoculum (photo 10).

Photo 10: Symptoms of brown spot disease Source[6]: AfricaRice**, 2012**

The fight against this disease is essentially based on the sanitation of the field, crop rotations, the respect of the crop calendar, the balanced manure, the chemical control and the improvement of the varietal resistance. Recent data suggest that appropriate soil nutrition is an important factor in controlling the disease [13, 51].

Rice blast: The blast caused by Magnaporte grisea (ascomycete filamentous fungus, fenomycete), whose anamorph is Pyricularia grisea, is the most serious and most serious fungal disease of rice[52]. The fungus attacks all aerial parts of the plant **(photo 11):** leaves, leaf sheaths, stem nodes, bases of panicles, rachis and lemmas[13]. It belongs to the class of Deuteromycettes, in particular Ascomyetes, the order of Moniliales, the family of Moniliaceae hyalofragmiées and the genus Pyricularia. The blast is present on all continents and in

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all cropping systems. On the leaves, the symptoms appear as small greyish brown dots that quickly become typical lesions, brown with greyish or whitish centers. In the most severe cases, the leaves become entirely brown and cause the disappearance of the plant[45]. On the panicle, the symptoms are mainly at the panicle node which turns brown, sometimes whitish (photo 11). The most serious attacks cause complete sterility of the grains followed by the breaking of the panicle at the node. The blast of knots, like that of the neck, is manifested by brown-blackish rot or disorganization of the tissues and causes breakage of the stem or base of panicles[13].

Leaf scald: The pathogen is initially known as Rhynchosporium oryzae. It is of cryptogamic origin and exists in all rice-growing ecosystems despite its notorious predominance under rainfed ecosystem. It is practically found in all West African countries, where it is particularly prevalent in humid zones, especially in the regions of Côte d'Ivoire, Liberia and Sierra Leone[13]. . The fungus is able to infect all the aerial parts of the plant at all stages of its development. Its lesions are generally zoned taking into account any transmissions caused by the contaminated seeds **(photo 12).** However, attacks are particularly frequent and severe on leaf limbs. Control methods are mainly based on cultural practices such as the use of healthy and uninfected seeds, the destruction of contaminated leaf tissue and tillers of dry plants, the use of crop rotation as much as possible. Since excessive fertilization of nitrogen fertilizers increases the sensitivity of rice to the disease, it is advisable to make applications

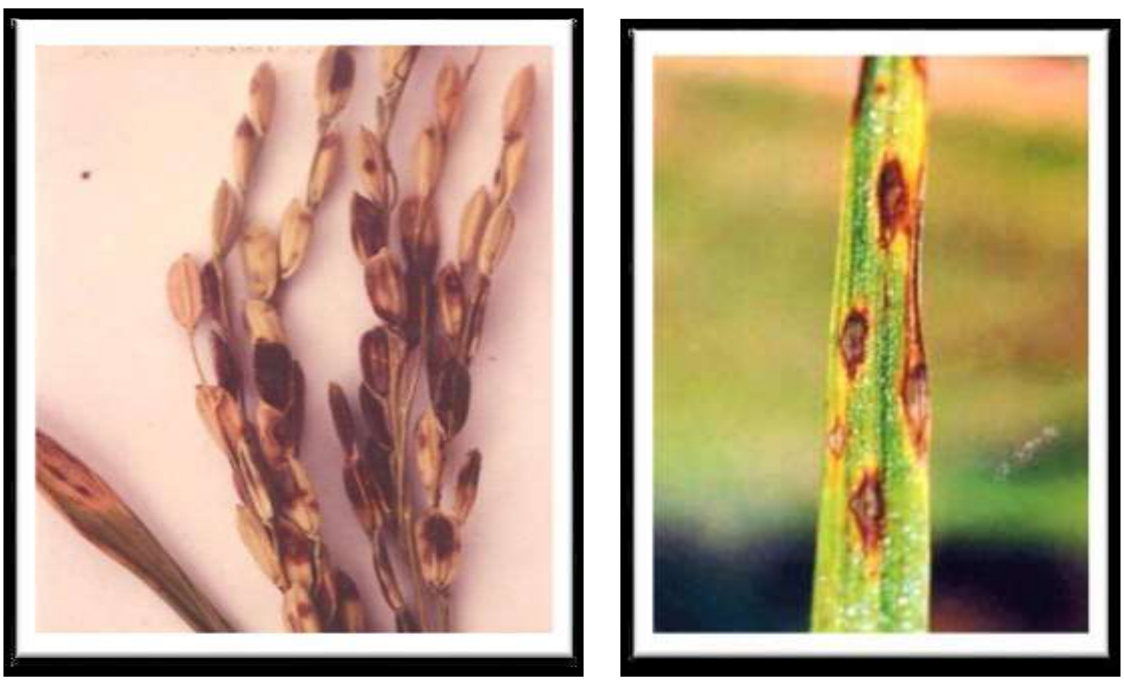

Photo 11: Symptoms of rice blast [6]

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Photo 12: Symptoms of leaf scald disease [6]

False coal: The causative agent is Ustilaginoidea virens. The seeds transformed into clusters of the vector turn yellow and turn from dark brown to black **(photo 13).** Some grains of the panicle become balls, greenish spores, and velvety appearance[13]. These early small balls are distinguished between glumes. They reach then 1cm of diameter or more and enclose the floral organs. Soil sclerotia that germinate in the growing season produce spores and infect the flowers. The membrane bursts under the effect of swelling and the ball becomes orange then yellowish green or greenish black. In general, only a few grains are contaminated inside the panicle, although sometimes they can be numerous. The disease is more serious for rainfed rice than for aquatic rice[19]. Indeed the disease does not cause significant losses the control method is based on, the use of crop rotation as much as possible; dried up and burned the contaminated fields.

Photo 13: Symptoms of fake coal source disease[6]

Rice virescence or mildew: The disease is caused by excess moisture in an area, leading to bacteria and musty odors that are difficult to remove[15]. Nevertheless, there are products that seem to reduce moisture and mold, including dehumidifiers. Mildew destroys the leaves of the rice plant and damages the panicles **(photo 14).** The most effective weapon against mildew is the selection of resistant varieties

Photo 14: Late blight symptoms of rice Source: Séré et al (2010)

Sheath rot: It is caused by Sarocladium oryzae and occurs on the upper sheath that covers the young panicles. The lesions start as irregular oblong spots 0.5-1.5 cm long followed by a brown margin and a gray center or entirely greyish brown. The most severe symptoms appear on upper leaf sheaths including the young panicle in the chest stage **(photo 15).** It grows and coats most of the sheath[52]. Young panicles rot in the sheath or partially emerge. Inside the contaminated sheaths there is an abundant white powdery material as well as young rotten panicles[13]. Control methods are based on cultural practices, with the use of healthy and unharmed seeds; other techniques prevent injury from insects, such as stem miners, as they facilitate infection and thus worsen the disease. Remove and burn the contaminated plants very often, plan the planting of the rice so that the periods of time unfavorable to the development of the disease coincide with the various stages of vulnerability of the plant. The incidence of the disease is reduced by increasing potassium intake. Finally, use cultivars resistant to rotting sheath.

Photo 15: Symptoms of canopy rot

Sigatoka of rice: The narrow brown spot (also called narrow brown leaf spot, or rice leaf spot of cercospora) is caused by the fungus Sphaerulina oryzina (Syn.cercospora janseana, Cercospora oryzae) and can infect leaves, sheaths and panicles[53].

The causative agent and symptoms of Sigatoka rice: The agent responsible for cercoporosis of rice is sphaerulina oryzina. After infection with sphaerulina oryzina, linear lesions appear between 2 and 10 mm long and generally between 1 and 1.5 mm wide. The major axis is parallel to that of the leaf. . The lesions have a dark brown center and the border fades when the external margin is reached [53]. The lesions on the sheath are similar to those of the leaf, while lesions on the glumes are shorter and tend to spread laterally. Pedicels and glumes can also be infected. Symptoms are usually extensive during the later stages of growth, with lesions appearing just before anthesis (opening of the flower) (photo 16). The disease can cause the premature maturation of the nuclei and the deposition of the plants. Sphaerulina oryzina infection may cause purplish brown discoloration of seeds or grain. It is one of many fungi associated with discolouration. It causes premature death of leaves and leaf sheaths, premature maturation of the seeds and, in severe cases, total destruction of the plants. Sigatoka has been reported in the tropical and subtropical rice regions of Asia, Africa, Australia and North, Central and South America and Papua New Guinea. The disease is usually found in potassium-deficient soils and in areas where the temperature varies between 25 and 28 ° C. It appears late, during the heading stage. The plants are more sensitive at the beginning of the panicle phase, and the damage becomes more serious as the plants mature.

The lesions are typical on the leaves and the upper leaf sheath, are light brown to dark brown, linear and progress parallel to the vein[53]. Leaf lesions of very sensitive varieties can enlarge and bind together, forming brown, linear necrotic regions. On the glumes, the lesions are usually shorter but may be wider than those of the leaves. Brown lesions are also found on the pedicels. The disease also causes discoloration of the leaf sheath, known as the "net spot", due to the reticulate form of the brown and light brown to yellow areas. Linear lesions make the disease distinct from other leaf diseases[53].

Photo 16: Sigatoka symptoms Source: www.invasive.org

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The mode of transmission, infection and development of Sigatoka of rice: The pathogen overwinters as spores in infected plant debris **(photo 17).** The fungus produces new spores in the spring that reinfect the rice. The spores are carried by wind and torrential rains. The movement can be over long distances[53].

Photo 17: Residues of rice straws, pathogens of black Sigatoka[54]

Methods for controlling Sigatoka of rice: Significant damage caused by a narrow brown spot decreases the market value of the grain and reduces the recovery of the milling. In terms of yield loss, only occasional severe outbreaks are known; and generally, the narrow brown spot has no significant economic implications. It is therefore important to find appropriate methods of struggle.

Use resistant varieties. Keep the fields clean. Remove weeds and the remaining rice from the field and surrounding areas to eliminate alternative hosts that allow the fungus to survive and infect new rice crops [53]. Use balanced nutrients; make sure the proper potassium is used. If a narrow brown spot (symptoms) appears and is a risk to the field, spray propiconazole at the start of treatment. Avoid late sowing, do not over fertilize the soil with fertilizer rich in nitrogen[54].

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DISCUSSION

Sigatoka leaf spot is a foliar disease that can be observed on all five continents, with a predominance in Africa according to Don G et al.[53]. From our review, it appears that Sigatoka leaf spot is a rare disease in rice paddy fields in Africa. West, but it could become a major disease if we do not try to study it better and know it better. Rice is a cereal grown on five continents with varying ecological diversity. The largest rice producers are Asians, and they are also the main consumers [14]. The main regions of rice activities in Africa are its West and East zones, which account for nearly 95% of production, this is confirmed by the results of Sié et al.,[15] . But rainfall, adverse climatic conditions and the reduction cultivable land with the profile of other crops such as wheat, but, cocoa ... could see decreasing rice production in the West African zone. There are several types of rice growing, but only a few are practiced in West Africa, especially rainfed rice (60% of cultivated area) and freshwater rice (27.5% of cultivated area) [37]. The reduction of arable land proves to be a serious problem for rice production in West Africa. Rice production is facing enormous abiotic and biotic constraints. Among the abiotic constraints depending on the types of rice cultivation practiced in West Africa, particularly strict rainfed rice cultivation, drought, temperature, soil acidity are the major constraints to rice production. These results are in line with those of WARDA[37]. For those who are biotic constraints to rice production, they are numerous but do not have the same degree of virulence. We have among others weeds that compete with rice, it is Scleria tessellata, Panicum repens, Leersia hexandra, Lipocarpha chinensis, Rottboelia cochinchinensis . Those who compete with rice for soil nutrients, when their numbers are large they can cause a decline in yield[41]. According to GNANCADJA *et al*.[54], the more the surface of the panicle leaf is damaged, the lower the number of solid seeds diminished. Various diseases are observable on rice, viral diseases, the best known is the yellow rice variegation caused by RYMV can cause a loss of up to 90%. Bacterial diseases are also observed the most devastating bacterial wilt caused Xanthomonas oryzae pv. Oryzae[13]. Nematodes are also observable in paddy fields that can cause huge losses according to Arraudeau [44], 40 kinds of nematodes are associated with rice worldwide. The diseases caused by fungi have been responsible for decades of huge loss related to rice production the most known and most devastating are Pyriculriose caused by Magnaporte grisea, the Helminthosporiosis caused by Drechslera oryzae called major disease. According to Silué, [52] the most serious and most serious fungal disease of rice is fire blast. Some fungal diseases are characterized in West Africa by minor diseases confirmed by Wopereis *et al*.[12], these include: false char, white gall, bacterial streaks, sheath rot, stubble diseases, discoloration of sheaths, gigantism and Sigatoka.

According to Sonko, "there are many cases of rice diseases; the most common in Casamance is Sigatoka, which is a foliar fungal disease[55]". It must be said that this rice disease, which seriously prevents the achievement of certain thresholds of production in the southern part of the country, is mainly caused by Sphaerulina oryzina. Don, G., et al [53]states that Sigatoka can infect rice from seedling stage to maturity, but in the United States the disease usually develops after transplanting and can cause considerable loss if is not treated in time. In Mauritani Marnotte P.[56], states that the sunshine and hygrometry of semi-arid zones are not favorable for the development of fungal diseases such as the most dangerous blast fever for rice, Sigatoka and rynchosporiosis. But the variation of a single climatic factor may be sufficient to create epidemiological conditions peculiar to the rapid explosion of one of them. In Burkina Faso, Sigatoka disease, considered as a minor ailment since 2016, is beginning to cause a lot of damage in the Kou rice valley, but no serious study has been conducted on the pathology. In Benin no study has been conducted on Sigatoka disease, it is not observable in all the rice growing areas, even when it is observed it does not cause huge damage because it

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has a low density. It should also be noted that peasants do not know how to recognize this disease because the symptoms are similar to and associated with those of other fungal diseases. Black Sigatoka is present in Benin because we have observed it in the rice fields of ZINVIE, ADJEHOUN, GOUTI, and according to its mode of transmission through debris, soil or runoff from torrential waters, it could be a devastating disease in coming years, especially since the rice production system is based on monoculture. Sigatoka can be inadvertently maintained by producers because they do not know the symptoms. Preventive control methods should be considered by involving producers. Cultural methods (alternation of culture, destruction of infected crop residues), the use of resistant varieties. Most so-called resistant varieties have not been tested for Sigatoka at high pressure. Sigatoka can cause severe damage to susceptible varieties by reducing the green surface of leaves, causing leaf death, but it has a low economic impact on resistant cultivars. Our work consisted in taking stock of the activities carried out on Sigatoka disease but it turns out that very few studies have been carried out on this disease, if that makes our work complex and interesting because it will make it possible to clarify this disease. Pathology that is raging in West Africa.

CONCLUSION

Foliar diseases are still an important factor in reducing plant productivity. To improve our knowledge of fungal diseases of rice including that of Sigatoka. Research based on severity, prevalence, mode of transmission, symptoms on this disease have been conclusive. In fact, Sigatoka forms with other diseases a parasitic complex. In the field, no study has been carried out to show how foliar diseases of rice are established in the Benin rice fields. The epidemiology of these rice diseases needs to be clarified. In this sense, it is important to think of a preventive control program that includes cultivation, disposal of crop residues, use of resistant varieties and seed treatment. This will provide an opportunity to rule out some diseases outside the field and prevent the introduction of virulent breeds. According to Rapilly[57], some cultural practices such as plowing and rotations can greatly reduce the amount of inoculum produced by the pests that persist on crop debris. Attack of the panicle leaf disturbs the storage of sugars in the grains. In addition, the presence of this mycoflor may have a considerable influence on production. At the end of this general study on rice, rice diseases, we remember that rice is an important cereal in men's lives because it is a staple food. But it is confronted with numerous parasitic pressures whose diseases which decrease its productivity it is thus important to be interested in these pathogens in order to protect our cultures against the losses caused

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