

# Principal Disease and Insect Pests of *Jatropha curcas* L. in the Lower Valley of the Senegal River

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## Summary

*Jatropha curcas* L. seed oil is proven to be toxic to many microorganisms, insects and animals. Despite its toxicity, *Jatropha* is not pest and disease resistant. The following major pests and diseases affecting *Jatropha* in the lower valley of the Senegal river have been identified: the leaf miner *Stomphastis thraustica* (Meyrick, 1908) (Lepidoptera, Gracillariidae), the leaf and stem miner *Pempelia morosalis* (Saalmüller, 1880) (Lepidoptera, Pyralidae) and the shield-backed bug *Calidea panaethiopica* (Kirkaldy, 1909) (Heteroptera, Scutelleridae), which can cause flower and fruit abortion. Damage from these pests was particularly great during the second year after the plantations were set up (2009) and before later receding. Nevertheless, the worst attacks were caused by a vascular disease transmitted through the soil, which killed 65% of the plants in four years. It is mainly characterised by collar and root rot, which causes foliage to yellow and wilt, before the plant eventually dies. These threats should increase if larger areas are planted with *Jatropha*. Considering the scale of the damage caused by these attacks in Bokhol, the development of an integrated pest management programme adapted to the local context should be considered.

## Résumé

### Les principaux bio-agresseurs de *Jatropha curcas* L. dans la vallée du fleuve Sénégal

Bien que l'huile de *Jatropha curcas* L. s'avère très toxique pour de nombreux microorganismes, insectes et animaux, les plantes de cette espèce subissent d'importantes attaques de différents bio-agresseurs. Les principaux ravageurs et maladies du *Jatropha* dans la basse vallée du fleuve Sénégal ont été identifiés. Il s'agit de la mite mineuse de feuilles *Stomphastis thraustica* (Meyrick, 1908) (Lepidoptera, Gracillariidae), de la mite mineuse de tige *Pempelia morosalis* (Saalmüller, 1880) (Lepidoptera, Pyralidae) et de la punaise *Calidea panaethiopica* (Kirkaldy, 1909) (Heteroptera, Scutelleridae) qui peut causer l'avortement des fleurs et des fruits. Les dégâts causés par ces ravageurs ont été particulièrement importants au cours de la deuxième année qui a suivi l'installation des plantations (2009) puis se sont estompés par la suite. De très fortes attaques dues à une maladie vasculaire transmise par le sol ont par contre causé 65% de mortalité des plantations après quatre ans de culture. Les symptômes de cette maladie sont la pourriture au niveau des racines, du collet et des tiges, le jaunissement et le flétrissement du feuillage et finalement la mort de la plante. Ces menaces ne devraient que s'amplifier en cas d'extension majeure des superficies plantées en *Jatropha*. Dans cette hypothèse, le développement de programmes de protection phytosanitaire adaptés au contexte local devra être envisagé.

## Introduction

For several years, the cultivation of *Jatropha curcas* L. has been considered one of the most promising solutions to the problems created by climate changes, energy insecurity and rural poverty in developing countries (1). *Jatropha* is a shrub, which is very drought-resistant and is cultivated as a hedge in most tropical countries (12). In Senegal, it is found mainly in the south of the country, in the form of hedges used to protect fields and home gardens against wild animals. The plant has many medicinal properties

and the extract obtained from its leaves is used as a nematicide (17, 35). The oil from its grains has proven to be highly toxic for many microorganisms, insects and animals, mainly due to its phorbol ester content (21). It can therefore be used as a microbicide, fungicide, insecticide, molluscicide, piscicide and rodenticide (2, 5, 8, 20, 28, 31). Nevertheless, the main economic advantage of this oil remains its use as an agrofuel (1). Despite its toxicity, *Jatropha* is infested by many insect pests and often shows symptoms of

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fungus attacks. Significant losses have been reported, following damage caused by insects, fungi or viruses (7, 9, 23, 29, 30).

Several pilot initiatives have been implemented in Senegal, in order to evaluate the true potentials of *Jatropha* in terms of combating rural poverty in Sudano-Sahelian Africa (33). These projects have highlighted the existence of pest insects and pathogenic fungi, which attack the plant in all regions, where its cultivation has been tested. In this study, we will outline observations concerning the main biopests affecting the *Jatropha*, which were identified during one of these projects. This pilot initiative started in September 2007 in the rural community of Bokhol (Département of Dagana, Region of Saint-Louis), with the aim of determining whether it would be possible to cultivate *Jatropha* sustainably on a large scale on marginal land in the lower Senegal river valley. The crops were monitored for four years.

## Materials and methods

### Study area and source of data analysed

The observations were based on six hectares of

*Jatropha* cultivated under drip irrigation close to the Senegal river between September 2007 - April 2008 at the village of Bokhol (Lat. 16°31'N, Long. 15°23'W) in the Saint-Louis region. The six hectares were divided into twelve half-hectare plots. The climate is of the BWh type (Sahelian climate) according to the classification of Köppen. Its annual rainfall falls between 180 and 300 mm over three months of the rainy season (from late June - late September). The average annual daily temperature is higher than 23 °C, the average minimum annual temperature is 18 °C and the average maximum annual temperature is 37 °C. Temperatures can fall to below 10 °C at night, between late December and late February, and can exceed 41 °C during very hot periods in May. The terrain is completely flat and the plantation was established on *Dieri* type soil, which corresponds to the flood-proof land of the river valley, which is a pastoral zone. On average, the soils at the Bokhol site contain over 90% sand (fine and coarse) in the arable horizon and are slightly richer in clay at lower levels. Their organic matter content is very low (< 1%) and they have a very low chemical content (CEC between 2 - 3 meq/100g soil).

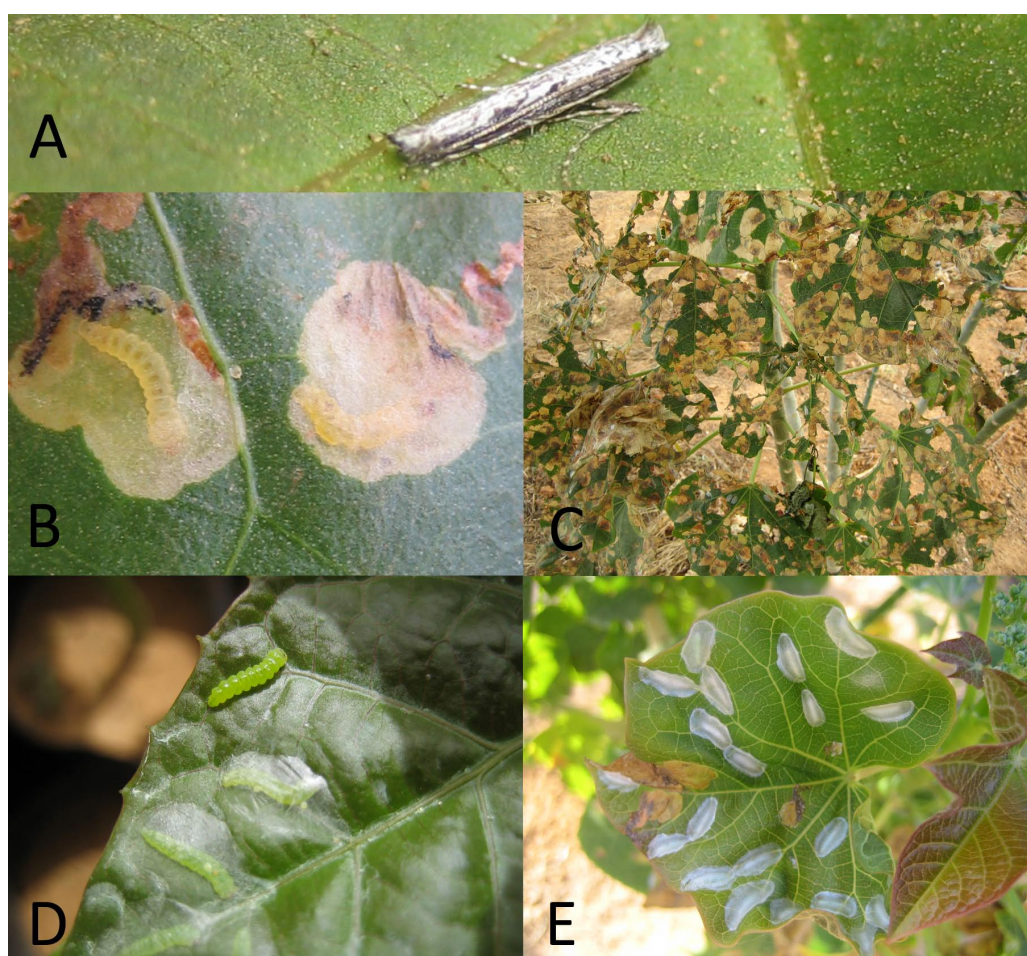


Figure 1: Life cycle of *S. thraustica*. The adults (A) lay their eggs on the *Jatropha* leaves. The larvae (B) dig tunnels in the leaf blade, which cause the leaves to dry out (C). Pupation takes place on the leaf surface (D), where the pupae enclose themselves in characteristic small white webs, which give the foliage a speckled appearance (E).

### Identification of insect pests and fungal strains

Samples of the main insect pests founded at Bokhol were identified at the Functional and Evolutive Entomology Unit at Gembloux Agro-Bio Tech – University of Liège.

### Quantifying the impact of phytosanitary problems

The vigorous nature of the attacks and scale of damage caused by *Jatropha* pest insects were quantified in 2009, using incidence and damage scales on randomly selected plants in the cultivated plots. The presence of pests and the damage that they cause formed the subject of qualitative observations in subsequent years (2010 and 2011).

The number of plants presenting phytopathological problems was quantified between March 2009 – September 2011.

## Results and discussion

### Identification of bio-pests present at the Bokhol site

Three pest insects attack the *Jatropha* at the Bokhol site: the leaf miner *Stomphastis thraustica* (Meyrick, 1908) (Lepidoptera, Gracillariidae), the leaf and stem miner *Pempelia morosalis* (Saalmuller, 1880) (Lepidoptera, Pyralidae) and the shield-backed bug *Calidea panaethiopica* (Kirkaldy, 1909) (Heteroptera, Scutelleridae), which can cause flower and fruit abortion.

Over 60% of the *Jatropha* plants at the Bokhol plantation fell victim to attacks by a soil-borne vascular disease.

### Quantifying the impact of the main pest insects *S. thraustica*

The presence of *S. thraustica* can be seen in the increasingly large brown patches on the leaves. These patches are caused by the tiny insect larvae, which eat away at the leaf blades, by digging tunnels into them. Pupation takes place on the leaf surface, where pupae enclose themselves in characteristic small white webs, which give the foliage a speckled appearance (Figure 1). Lepidoptera, in their adult form, are nocturnal. They can only be observed rarely on the plants.

The Bokhol plantation suffered very strong attacks by the leaf miner from late 2008 onwards (1½ years after planting) and after early March 2009 when foliage reappeared on the plants at the end of the cold and dry season. During this period between 25 March - 22 April 2009, the incidence and damage caused by the leaf miner were quantified using samples taken from 12 randomly selected plants from each half-hectare block (a total of 10 blocks were observed, as the plantations set up in the last two blocks covered no more than 20% of their surface), using scales based the percentage of affected plants, the percentage of

attacked leafs per plant and the proportion of damaged surface per leaf. The incidence of attacks caused by *S. thraustica* grew worse during the observation period. The percentage of attacked plants increased from  $70 \pm 23\%$ , when the observation began, to  $98 \pm 6\%$  at the end of the observation. The number of leaves suffering from damage also increased during this period. On average,  $22 \pm 3\%$  leaves were mined per plant at the start of the observation, compared to  $32 \pm 13\%$  at the end of the study. The severity of the attacks, calculated according to the amount of leaf surface damaged, increased from  $7 \pm 7\%$  to  $24 \pm 1\%$  at the end of the observation period. It could be observed that the miner population began to increase less quickly at the end of the dry season, which is characterised by a steep rise in temperatures. During the next two years (2010-2011), leaf miner attacks continued to be observed, but their incidence and the damage they caused were significantly reduced.

Attacks by *S. thraustica* have also been reported on *Jatropha* in many countries, such as India (4, 34), Kenya (25), Malaysia (32), Mozambique (6), DRC (22) and China (40, 41). In Senegal, this pest has been observed in the Departement of Foundiougne (13, 36) and the Departement of Tambacounda (37).

### *P. morosalis*

*P. morosalis* larvae feed on leaves and pollen during their wandering phase, which can be observed by the presence of webs and droppings on the inflorescences. They penetrate into the stem by digging tunnels, in order to complete their development (Figure 2). They can cause damage to the inflorescences and stems, which makes the later non-functional, while fruits are also attacked (34). This insect has been observed in Bokhol since 2008. Its proliferation seems to follow the level of development of the plant foliage. It had practically disappeared during the plants' defoliation phase between late December 2008 and late February 2009, but its attacks resumed with the return of foliage in March 2009. Due to the risk associated with its presence, quantified monitoring of attacks by this insect was conducted during the period between 27 March - 22 April 2009, using samples from twelve randomly selected plants per half-hectare block (in total, ten blocks were analysed). This monitoring involved evaluating the percentage of plants attacked at the plantation and measuring the length of stem sections that had been mined by *P. morosalis* larvae. The percentage of plants affected increased from 2 - 12% during the observation period. In the majority of cases (64%), the length of the sections being attacked was less than 5 cm. On 29% of the attacked stems, the length of the mined sections ranged from 5 - 15 cm. Only 7% of the attacked stems presented a mined section that was longer than 15 cm. The level of attacks by *P. morosalis* did not increase significantly during the next two years.

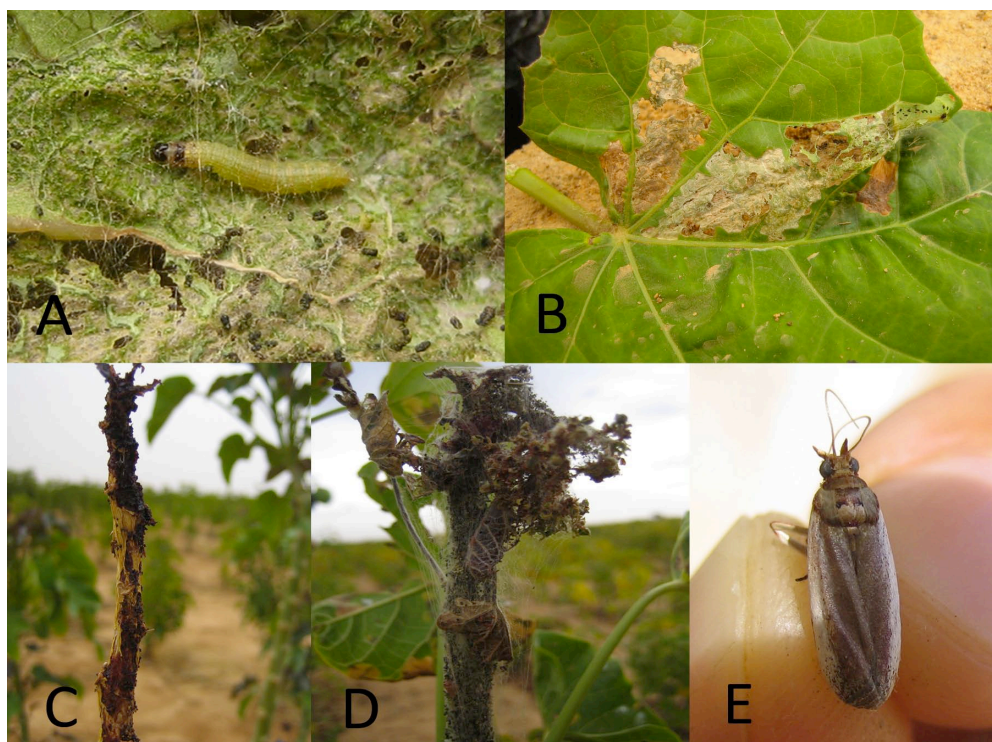


Figure 2: Life cycle of *P. morosalis*. The larvae feed on the leaves (A and B), branches (C) and inflorescences (D). They penetrate into the stem, by digging tunnels, in order to complete their development. Adult *P. morosalis* (E).

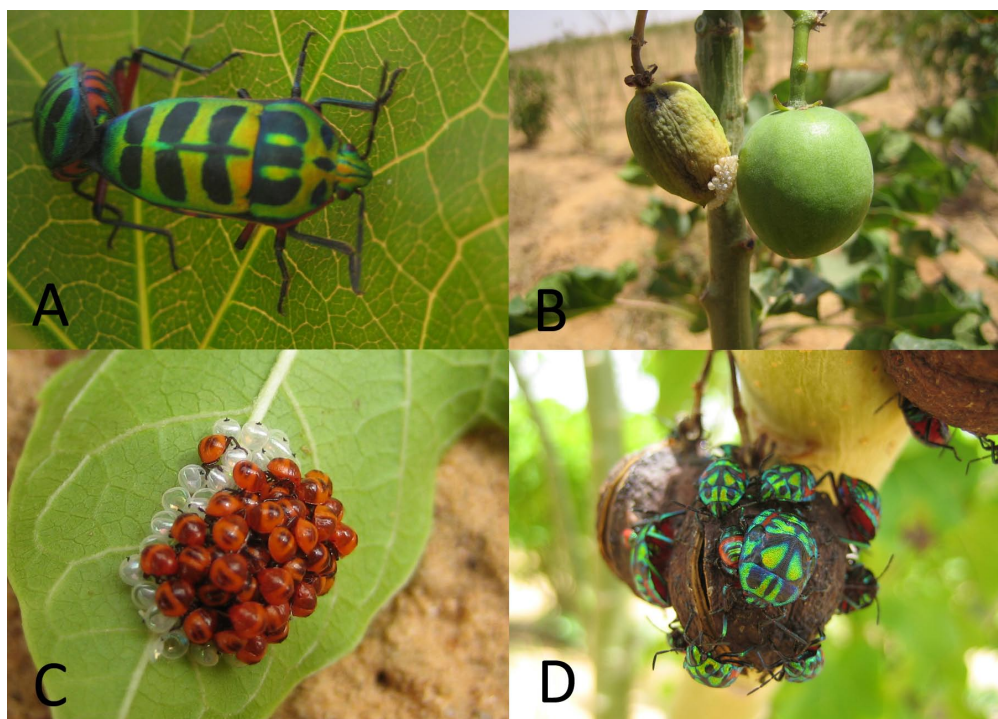


Figure 3: Adult *C. panaethiopica* (A) lay their eggs on the fruits (B) and leaves (C). The larvae and adults feed on the capsules using their stinging rostrum (D).

Classed as the second worst pest in India by Shanker and Dhyani (34), *P. morosalis* has also been identified as an enemy of *J. curcas* in Kenya (25), Madagascar (24), Mali (3) and Cambodia (27). *Pempelia morosalis* presents a wide geographical distribution. In reality, this is not really a biological species but a complex

of species, which cannot be differentiated using morphological criteria. This complex of cryptic species was recently assigned to a new genus (14) and should be considered as *Morosaphycita morosalis* sensu lato (Saalmüller, 1880). For the purpose of clarity and simplification, we opted to use the still widely used

term, *Pempelia morosalis*, without referring to the species complex.

### ***C. panaethiopica***

The adult *C. panaethiopica* shield-backed bug attacks the flowers and capsules, on which they feed using their stinging/sucking rostrum (Figure 3). They are likely to cause the capsule deformation and abortion. In addition, this is where they lay their eggs, which are likely, in turn, to cause damage to the capsule. The adults arrive on the plants at the end of March.

The females arrive first and immediately lay their eggs on the lower leaf surfaces and capsules. At the end of April 2009, we observed percentages of attacked capsules ranging from 6 - 33% in the various blocks at the plantation. Per hectare, the number of individuals observed ranged from 417 - 3750 individuals (1256 on average). During the rainy season, all stages of the pest cycle co-exist simultaneously on the plants.

Of the 39 Heteroptera species observed on *Jatropha* crops in Nicaragua, identified by Grimm and Führer (10) and Grimm and Somarriba (11), the following two species are the most harmful: *Pachycoris klugii* (Burmeister, 1835) (Heteroptera, Scutelleridae) and *Leptoglossus zonatus* (Dallas, 1852) (Heteroptera, Coreidae). In India, the species *Scutellera nobilis* (Fabricius, 1775) (Heteroptera, Scutelleridae) represents one of the main *Jatropha* pests (34). These Heteroptera cause flower and fruit abortion, reduced

size, weight and oil content in seeds, as well as “embryo” abortion, which leads to large proportions of empty grains. *P. klugii* feeds on fruits and is able to sequester phorbol esters, which it uses as a defence mechanism against its predators (38). Other species of Scutelleridae have been observed on *Jatropha* in Mali (3), DRC (22) and Kenya (25).

Several Scutelleridae species therefore seem to be closely linked to *Jatropha* and this family can be considered one of the main groups of *Jatropha* pests in the world. In eastern Senegal, another bug of the *Calidea* genus has also been observed on *Jatropha* (37). This same species has also been observed west of the Groundnut Basin (Département of Foundiougne) (22).

### **Quantifying the impact of vascular disease**

The *Jatropha* plantation at Bokhol suffered severe attacks by a vascular disease that caused major damage. Plants that were subject to water stress were particularly vulnerable to these attacks. This disease, which is present in the vessels, causes root and collar rot, which leads to yellowing of the leaves, stem and ultimately withering of the foliage and drying out of branches (Figure 4). Termites are attracted by the rotting odour and ravage the entire plant. When the roots and collar are completely eaten away, the plant falls under the effect of its weight. The disease also leads to the presence of black lines on the vessels in the plant’s stem and branches.

The first outbreak of the disease occurred on a half-

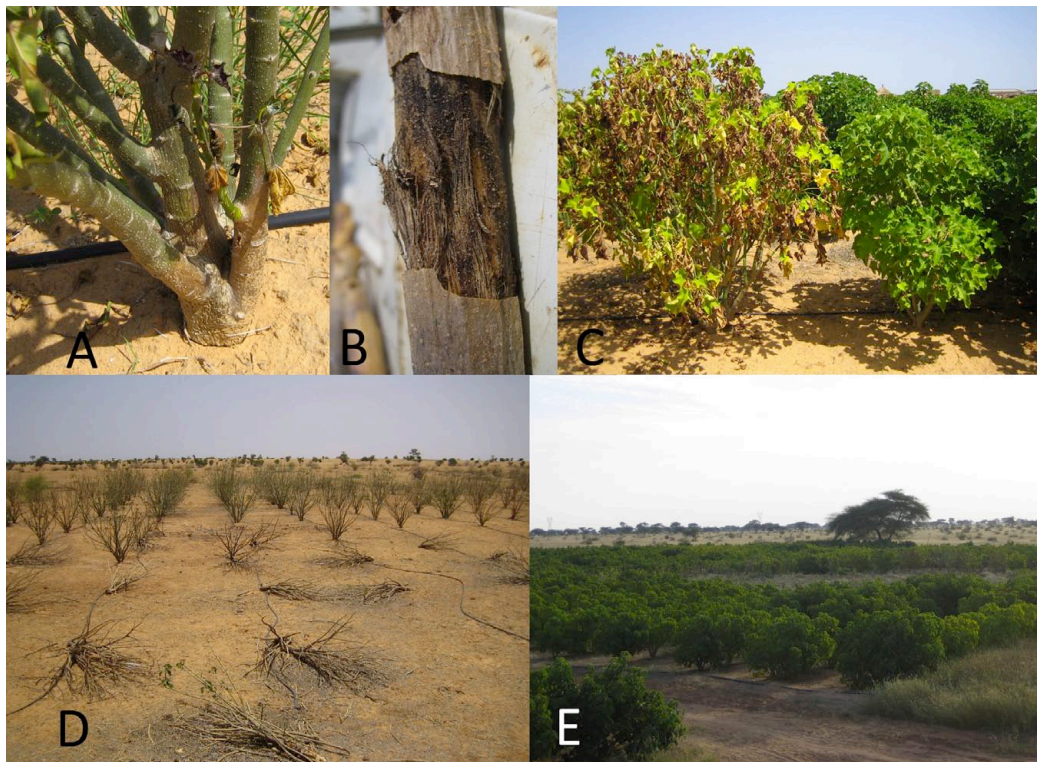


Figure 4: The presence of vascular disease causes the roots, collar (A) branches (B) to rot, which leads to yellowing and withering of the leaves (C). Termites are attracted by the rotting odour and ravage the entire plant (D). The disease spreads as a circular outbreak (E).

hectare area at the start of the second year after planting and caused 17% of plant deaths in that year. The disease then spread closer and closer in circular outbreaks, starting from sick plants (Figure 5). Various anti-fungal treatments (sulphur, thiophanate-methyl, copper oxychloride and benomyl) were applied in order to control this disease, but none of them proved effective. Mortality increased from 16% of all dead plants across the entire field in the second year to 36% in the third year and 65% in the fourth year. At the end of the observations, two thirds of the six hectares of the plantation were ravaged. No stabilisation of the disease was detected. The disease spread from clearly localised outbreaks to the various plots, which were added over the years (Figure 5).

Similar damage was observed on other rain-fed *Jatropha* crops on plantations in eastern Senegal and west of the Groundnut Basin. However, the mortality rate there was generally lower than that observed in Bokhol. It is possible that the prevailing environmental conditions in northern Senegal stress the plants and make them more vulnerable to attacks.

In addition, the irrigation system put into place creates favourable conditions for the development and spread of the pathogen, by maintaining constant humidity in the soil.

Fungal attacks on *Jatropha* are not well documented.

The consequences of root attacks are similar, as the plants are not able to absorb water. Four pathogens have already been identified as the cause of root rot in *Jatropha*: *Fusarium oxysporum* Schlecht. f. (15), *Macrophomina phaseolina* (Tassi) Goid, *Phomopsis longicolla* Hobbs, *Alternaria alternata* (Fr.) Keissler (18, 29). Attacks by *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. have been observed in India and Brazil, respectively, by Latha *et al.* (19) and by Pereira *et al.* (26) with the appearance of pycnidia on the collar. Similar symptoms can be observed in India, following attacks by *Fusarium moniliforme* Shel. (16) and *Botryosphaeria dothidea* (Mougeot: E.M. Fries) Cesati & De Notaris (29) and in China following attacks by *Nectria haematococca* Berk. & Broome (39).

### Conclusions

Contrary to popular opinion, the toxicity and insecticide properties of *J. curcas* fail to protect it fully against attacks by insects and diseases. The different parts of the plant are affected: roots, branches, leaves, flowers and fruits. These attacks affect the plant's productivity. Grimm (9) estimates that an 18.5% loss in harvest potential is caused by Heteroptera. Some Lepidoptera and Heteroptera observed in the course of our study represent major potential threats to *Jatropha* cultivation in Senegal and probably throughout Africa's entire Sudano-Sahelian region.

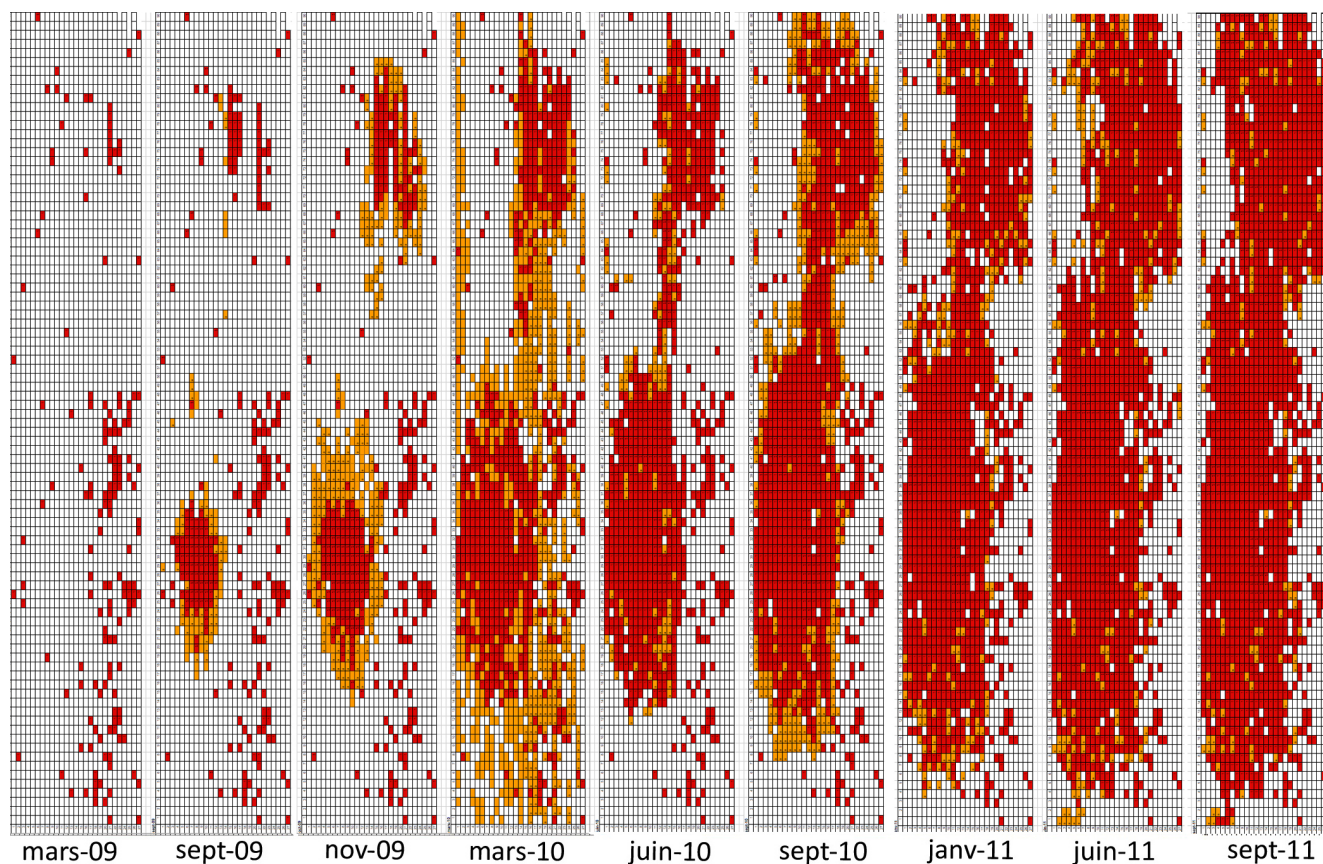


Figure 5: Development of vascular disease over a period of time (March 2009 – September 2011) on one hectare. The white spots represent healthy plants, the orange spots indicate diseased plants and red spots show dead plants.

These threats would increase if far larger areas were planted with *Jatropha*. The development of vascular diseases can also seriously threaten *Jatropha* crops. This type of disease is known, all over the world, to cause major damage to crops. The lack of effective chemical treatments poses a real problem. Due to the scale of the damage recorded at Bokhol, it is vital that the development of appropriate phytosanitary

protection programmes for the local context is considered, with the aim of increasing the number of areas planted with *Jatropha*.

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