

Incidence and severity of the facultative parasitic weed *Rhamphicarpa fistulosa* in lowland rainfed rice in southern Tanzania

J. Kayeke,^{1*} J. Rodenburg,² F. Mwalyego³ and R. Mghogho³

¹ Mikocheni Agricultural Research Institute, P.O. Box 6226, Dar es Salaam, Tanzania; ² Africa Rice Centre (AfricaRice), P.O. Box 33581, Dar es Salaam, Tanzania; ³ Uyole Agricultural Research Institute, P.O. Box 400, Mbeya, Tanzania.

Abstract

Rhamphicarpa fistulosa (Hochst.) Benth. is a facultative root-parasitic weed of the Orobanchaceae family. This weed has been reported in two districts in southern Tanzania, Kyela and Mbinga. A survey was conducted to determine the incidence and severity of *R. fistulosa* in rainfed rice production systems in these districts. Socio-economic factors related to rice production were identified and awareness was raised among key stakeholders. A survey was conducted in villages reported to have problems with this parasitic weed in rice, using structured questionnaires, group discussions and field observations. The majority of respondents had attended formal school (92%) and cultivated their own land (90%). Weed infestation was identified as major constraint to rice production. The order of importance of weed species was: *R. fistulosa* > *Oryza longistaminata* > *Cynodon dactylon* > *Striga asiatica*. According to farmers, *R. fistulosa* can inflict yield losses of 30–100% under severe infestation. At the time of the survey (2008), all of the respondents indicated that they were familiar with *R. fistulosa* — evidence of a progressive spread of the weed. Farmers knew the effect of the weed, but lacked knowledge on its biology. They presumed seed to be dispersed through flood water, grazing cattle in harvested rice fields, sharing farm implements and exchange of rice seed. Available control measures were hand weeding and herbicide application. Research is needed to understand the biology of this weed in order to develop integrated weed management strategies.

Introduction

Rice is an important cereal grown as food and cash crop in Tanzania. It has been ranked as a national strategic crop on the basis of the area under cultivation, production and consumption. However, average rice yield is very low (1.5 t/ha) compared to the estimated potential yields of 4–5 t/ha (Ministry of Agriculture Food Security and Cooperatives, 1998). Low actual yields are a result of poor-yielding varieties, depleted soil fertility, diseases and weed infestation. In the late 1990s, *Striga* spp. and *Rhamphicarpa fistulosa* were identified as important parasitic weeds hindering rice production (unpublished District Agric. Reports). *Striga* is found in rainfed uplands, whereas *Rhamphicarpa fistulosa* is found in rainfed lowlands and hydromorphic slopes. *Rhamphicarpa fistulosa*, a facultative hemi-parasitic weed, was first reported in Tanzania by Johnson *et al.* (1998). The weed was reported in Kyela and Mbinga Districts in southern Tanzania. These districts are dominated by rice-based farming systems (Mussei *et al.*, 1999). *Rhamphicarpa fistulosa* infestation reduces yield of lowland rice up to total crop failure depending on level of infestation. Presence of the weed has caused farmers to abandon their land. *Kyela District Agricultural Report* (1998) says that the weed had infested about 33% of rice-growing areas. All efforts to increase rice production, including introduction of lowland New Rice for Africa (NERICA) varieties, in the two affected districts are endangered by the presence of *R. fistulosa* in rice-growing areas.

A survey was conducted in the two districts, Kyela and Mbinga, to establish a benchmark and collect information on weed incidence, severity and socio-economic factors related to rice production, with the aim of finding pointers for future research and development efforts.

Materials and methods

Location

The study was conducted in two districts along Lake Malawi, Mbinga (10°15'–11° 34' N, 34°24'–35°28' E; 480–600 m a.s.l.) and Kyela (9°25'–9°40' N, 35°41' E; 400–500 m a.s.l.). These districts were selected as study areas as they represent the locations where the weed was first reported.

Both districts are characterized by warm temperatures (19–23°C in cool months and 29–31°C in warm months) and unimodal rainfall from November to May. Average annual rainfall is 1224 mm in Mbinga and 2000–3000 mm in Kyela (DADPS, 2007).

Survey

One survey was conducted, comprising a single visit and structured questionnaires following the methods of Coe (2004), Matata *et al.* (2001) and Kroschel (2001). Primary data were collected using a questionnaire and through a group discussion, while secondary data were obtained from available documentation with field observations for clarification and collecting more information. Data from the questionnaire were coded and analyzed using SPSS statistical package. The survey was conducted in villages where rice was grown as a major

* Corresponding author (email: jkayeke@yahoo.com).

crop: Mbamba bay in Mbinga District and Kilasilo, Ibungu and Kikusya in Kyela District. In these villages, only rice farmers with *Rhamphicarpa*-infested fields in lowland or hydromorphic zones were selected for interview. The total number of respondents was 64 (15 in Mbamba bay, 17 in Kilasilo, 18 in Ibungu and 14 in Kikusya), 75% of whom were younger than 50 years old.

Results

Of the interviewed rice farmers, 76.6% were male and 33.4% female. The majority (87%) of the households were headed by men. Most of the interviewed respondents (92%) had attended formal school (80% primary level and 12.5% secondary level).

There were five routes of obtaining land ownership: inheritance, purchasing, renting, borrowing and allocation by village government (Fig. 1). Most of those interviewed (90%) cultivated their owned land, while 10% rented or borrowed a piece of land for cultivation.

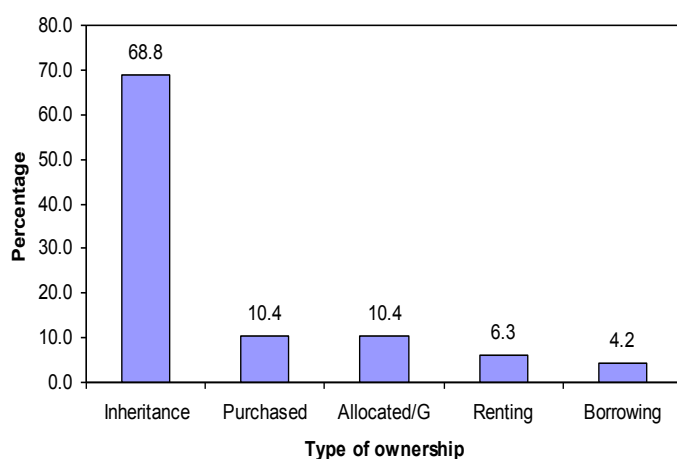


Figure 1. Percentage of respondents in different categories of land tenure.

Different crops are grown in the survey area, including rainfed rice, cassava, maize, groundnut, bambara nut, cacao, palm trees, banana and citrus fruits. Most of the crops grown were within or close to the homesteads (not more than 30 minutes walk). Farmers in the survey area also kept animals, including cattle, pigs, goats and chickens, but this only contributed 2% of their total income.

According to farmers, the five highest ranking constraints in rainfed lowland rice production were weed infestation, lack of farm implements, high price of inputs, unreliable rainfall and unavailability of inputs (Fig. 2). The most troublesome weeds of rainfed lowlands and hydromorphic soils mentioned, in decreasing order of importance, were: *Rhamphicarpa fistulosa*, *Oryza longistaminata*, *Cynodon dactylon* and *Striga asiatica*.

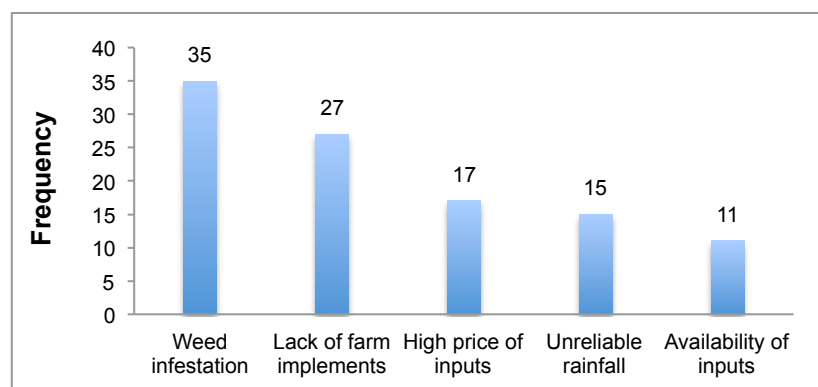


Figure 2. Constraints to rice production

Most of the interviewed farmers prepared the land using ox-plows (53%). A smaller number of rice farmers used only a hand-hoe (36%) or combinations of an ox-plow and tractor (9%) or ox-plow and hand-hoe (2%).

Among the respondents, 63.5% ranked their fields as fertile. This fertility was assessed through visual crop performance (93%), soil color (5%) or soil texture (2%). All respondents mentioned *Striga* infestation as a common biological indicator of low soil fertility in rainfed fields.

Only 36% of the respondents used inorganic fertilizers in their rice fields. Common inorganic fertilizers used are diammonium phosphate (DAP, 18–46–0) and urea (46% N). Farmers were unaware of good fertilizer application methods and timing. Many farmers broadcast DAP in rice fields immediately before the rice booting stage. Farmers did not measure application rates and they seldom consulted extension officers for appropriate fertilizer application. In four fields in Kilasilo, farmers rotated rice with *Crotalaria ochroleuca* (green manure) with the sole purpose of increasing soil fertility. Others used pigeon pea (*Cajanus cajan* (L.) Millsp.) for this purpose. Groundnut and bambara nut were grown solely for food and farmers were unaware of their soil-fertility improving traits. Green manuring and rotation with legumes were limited to upland fields.

Among the respondents, 64% used herbicides for weed control in rice. However, inappropriate products (ametryn) and application methods (knapsack sprayer fitted with insecticide nozzle) were commonly used. According to respondents, glyphosate, 2,4-D, amine and ametryn were the common herbicides used.

Between 1951 and 1960, only 3.2% of the respondents knew *R. fistulosa*, but by 2006 all respondents (100%) had seen the weed in flooded rice fields (Fig. 3). Among the interviewed farmers, 98% knew that *R. fistulosa* is found in temporarily submerged rainfed rice fields, while the remainder said it was found in waterlogged areas. According to 82% of the farmers, *R. fistulosa* was increasingly occupying lowland rice fields. Important causes for this increase, according to the farmers, were: cattle grazing in harvested fields, intensification of rice production (in both space and time), uncontrolled flooding, sharing of farm implements and exchange of rice seed among farmers. Other farmers associated spread of the weed with climate changes.

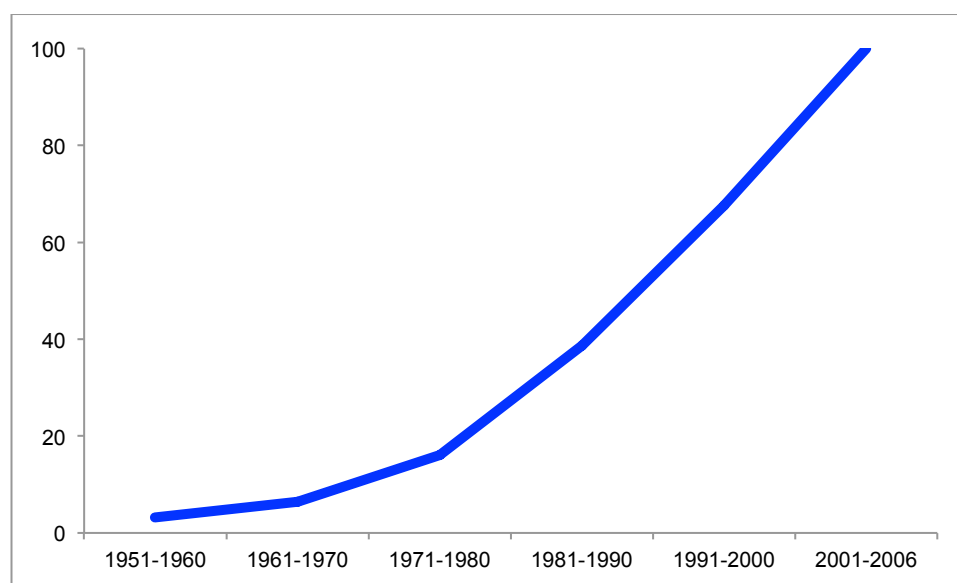


Figure 3. Percentage of respondents who knew *R. fistulosa*.

All respondents knew that *R. fistulosa* can inflict yield losses of 30–100% on rice under severe infestation. Affected rice plants show stunted growth with very low or no grain yield. However, none of the farmers possessed knowledge of the biology of the weed. Control measures practised by farmers to control *R. fistulosa* included weeding by hand or hoe, the use of fallow, and application of herbicides. None of the respondents indicated 100% effectiveness of any of these control measures.

Among the respondents, 50% had access to the extension services in their villages, but from this group, only 40% regularly consulted these services. Sources for agricultural information to farmers are as shown in Table 1.

Less than two-thirds (64%) of the respondents were aware of agricultural credit facilities, and only 21% had applied for credit. Respondents (64% of them) indicated that these low credit use rates resulted from the difficulties associated with accessing the credit.

Discussion

This study revealed the presence of a number of favorable factors for the development, dissemination and uptake of new technologies. First, the community was demographically relatively young. Age plays an important role in acceptance rate of innovations (Rogers and Shoemaker, 1971): the young generation is

Table 1. Sources of information

Source of information	Percentage of respondents
Research	7.3
Extension	27.3
Other farmers	25.5
Experience	20
NGO	1.8
Other farmers and experience	5.5
Extension and experience	10.9
Research and extension	1.8

expected to be more dynamic and ready to change. Second, the high literacy rate of the target group (92%) also favors uptake of information and new technologies. The level of education plays a significantly positive role in influencing adoption of introduced technologies in a society (Rogers and Shoemaker, 1971): those with a high level of education are more ready to accept changes than those without education.

Third, about 90% of the respondents cultivated their own lands. This is important, as farmers often, logically, show a higher willingness to invest in the land if it is their own. Land tenure stimulates farmers to invest in agricultural technologies on their land and to embark on longer-term strategies (van den Ban and Hawkins, 1988). A fourth factor that could favor timely control of this production constraint in the area is the vicinity of extension services. Although few farmers used them, availability of such established information pathways (van den Ban and Hawkins, 1988) creates a potentially favorable environment for technology development and dissemination. Fifth, the availability of credit facilities creates a conducive environment for farmers to borrow money for investments in technologies to improve agricultural production.

Rhamphicarpa fistulosa received top ranking in terms of important weeds among rice farmers whose fields were infested with it. This is probably due to its devastating effect to rice and high invasiveness. Rice is also the only crop that can be grown in temporarily submerged areas where *R. fistulosa* thrives. High ranking of weeds as a production constraint to lowland rice in this study confirms reports from previous work carried out in this area (Kayeke, 2004). *Rhamphicarpa fistulosa* did not occur as a single weed species in rice fields, but rather as a component of a multi-species weed community. Therefore, technologies should not merely target control of *R. fistulosa* but contribute to the management of weeds in general.

The availability and use of ox-plows as a single or combined farm implement would facilitate proper land cultivation and potentially save time and labor that in turn could be used to improve land preparation (e.g. bunding and leveling) or for other labor-intensive operations (e.g. transplanting) that favor the crops' competitiveness against weeds. On the other hand, the use of animals and their implements without special care increases the risk of *Rhamphicarpa* seed dispersion. The introduction of bunds, to improve water management, has been identified as a possible control measure for *R. fistulosa* (Rodenburg *et al.*, 2010). Field observations suggest that where water is managed correctly (e.g. continuously flooding at controlled depth), *R. fistulosa* is kept under control. In the current study, farmers also indicated that *R. fistulosa* infestations are particularly high in years of good rains. This relationship should be studied further.

Early weeding and the application of proper amounts of fertilizer at appropriate times are also likely to benefit rice at the expense of *R. fistulosa*. None of these practices were broadly applied by rice farmers with *Rhamphicarpa*-infested fields in the study area. Weed infestation was higher in Kyela than in Mbinga, probably due to rice cultivation practices. Transplanting is another potentially beneficial technology that could aid in the control of the parasite. In Kyela, rice was sown by direct seeding (broadcasting) on dry land followed by flooding, but 5% of the interviewed farmers used bunds for water management in their fields. In Mbinga, however, rice was transplanted and farmers observed that transplanting reduces the infestation level of *R. fistulosa*. In transplanted rice, the crop has a time and size advantage over weeds, and when transplanting is done in lines, hand or hoe weeding is easier than in broadcast crops (e.g. Rodenburg and Johnson, 2009). The latter advantage was also observed by farmers in Mbinga in the current study. Transplanting is also one of the management practices for *Striga* (Parker and Riches, 1993). In Kyela, farmers practiced fallowing, but they had not observed a strong reduction in infestation level after this practice. Some fields which were abandoned for 6 years were highly infested the first season after fallowing. This could partly be due to the fact that *R. fistulosa* is a facultative hemi-parasite, that does not need a host to grow and reproduce (Ouedraogo *et al.*, 1999). Moreover, *R. fistulosa* can also parasitize natural (fallow) vegetation.

Empirical evidence of a correlation between *Rhamphicarpa* prevalence and poor water management, soil fertility or rice establishment methods (or a combination of these factors) is scant. But the few studies previously carried out on this parasitic weed indicate that improved crop management could be key to *R.*

fistulosa control (Rodenburg *et al.*, 2009a; Sikirou *et al.*, 2002). Improved crop management could be backed up by chemical control if necessary. The current study identified a clear lack of awareness of the proper use of herbicides among respondents. Therefore, training on herbicide application as a component of integrated weed management (IWM) is very important to rice farmers.

Rhaphicarpa fistulosa is well known by most of the farmers in the infested area, and it has been given a number of vernacular names. In Kyela it is called *Mbosyo* meaning something that make things ‘rotten’, while in Mbinga it is called *Ntengo wa nchele-nchele* meaning the ‘salty’ plant. *Rhaphicarpa fistulosa* is spreading according to rice growers, and as such poses a threat to other rice-growing areas.

The common control measure used by many is hand weeding. Although effective, this practice is particularly labor intensive (Rodenburg *et al.*, 2009b, Rodenburg and Johnson, 2009). According to farmers, they weed up to three times to control *R. fistulosa* and other weeds. In case of parasitic weeds like *R. fistulosa*, hand weeding cannot prevent some damage to the crop, as the plant is allowed to grow, and parasitize, for some time before it can be hand pulled.

This study showed that farmers generally lacked any knowledge of the biology of *R. fistulosa*. Hence, rice farmers of this area could benefit from training on the biology of parasitic weeds in general and *Rhaphicarpa* in particular, linked to targeted control options. However, also on the scientific level, the biology of this species is not yet completely understood.

According to farmers, *R. fistulosa* emerges between 10 and 12 weeks after sowing in direct-seeded rice. In transplanted rice, *R. fistulosa* occurs at the same time as other weeds. This raises questions on the germination dynamics of *R. fistulosa*. Previous studies showed that *R. fistulosa* has similar germination requirements to *Striga angustifolia*: its seed needs to be exposed to light in order to germinate (Parker and Riches, 1993; Neumann *et al.*, 1998; Ouedraogo *et al.*, 1999). As *R. fistulosa* is a facultative parasite, one would expect it to germinate at the same time as other weeds. More knowledge on the germination requirements of *R. fistulosa* will provide pointers for effective control practices.

When the infestation was high (10–15 weeds per m²) farmers normally abandoned the field.

Conclusions

Rice, a national strategic crop in Tanzania, is facing a great threat from *R. fistulosa*. Success of efforts to increase rice production and productivity through increased area under rice and introduction of improved varieties (such as NERICA) are jeopardized due to its presence in potential rice-growing areas. Lack of formal seed system in the local rice sector, a lack of farmers’ knowledge on the biology of the weed, and limited scientific information contribute to this threat. The current study suggests that improved management practices combined with a targeted control strategy, based on biological and ecological knowledge, could help resource-poor rice farmers in rainfed lowland rice areas to manage weeds and parasitic weeds like *R. fistulosa* in their fields and obtain satisfactory crop yields. Concerted action in research, development and capacity-building is needed to stop the invasion of this parasitic weed and to reduce the damage it causes in already infested rainfed lowland rice fields in Tanzania and other tropical African countries.

Acknowledgements

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