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RESEARCH ARTICLE

Breeding opportunities and varietal preferences as per farmers' perceptions for development of striga (*Striga hermonthica)* resistant varieties and hybrids in maize

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Abstract

Participatory rural appraisal (PRA) is a way to consider farmers' and other stakeholders' perceptions in the development of new technologies including breeding methods and new varieties. Maize is a staple food for most farmers in Mali and is grown in almost all agro-ecological zones. The production of this crop faces several constraints. Focus group discussions and individual interviews using questionnaire were conducted in 6 villages in Bancoumana and Kolokani, two districts of Koulikoro region in Mali to determine the relative importance of *Striga* in relation to the maize production constraints and to lay the groundwork for breeding *Striga* resistant maize. Scoring and ranking techniques were used to assess farmers' preferences and constraints. A greater percentage 80% and 70% of responding farmers in Bancoumana and Kolokani, respectively, thought *Striga* is destructive to crops, while 70 % of the responding farmers in Kolokani linked *Striga* to low soil fertility. Farmers mostly grow local landraces of maize which are chosen for their taste and maturity. Uprooting and removing are *Striga* control measures used in both districts. Maize production is seriously limited by declining soil fertility, *Striga hermonthica*, and high cost of fertilizer. High grain yield, earliness and resistance to *Striga* are traits preferred by farmers.

Key words: *Zea mays*, farmer's perceptions, S*triga*, varietal preference

Introduction

Participatory rural appraisal (PRA) is a way to consider farmers' and other stakeholders' perceptions in the development of new technologies including breeding methods and new varieties (Werner, 1993; Chambers, 1994). Favoured methods for conducting PRAs include structured group discussions, following common guidelines or check lists, which typically include ranking of constraints and problems faced. DeVries and Toenniessen (2001) called for the involvement of farmers in the development process of new varieties. They proposed that farmers should be involved in all aspects of variety development including priority setting, early generation breeding, variety testing and selection so that breeders would obtain regular inputs from farmers that enable them to structure their selection indices accurately. This approach of breeding is called as participatory plant breeding where farmers are involved in evaluation and selection of variety. Farmers will get an opportunities to

make decisions at different stages during the process of varietal development. The failure of formal breeding programmes to achieve high adoption rates of improved varieties by farmers is well recognized (Singh and Morris, 1997). Participatory plant breeding exploits indigenous knowledge by involving farmers at different stages in the selection process. The materials identified or selected with the involvement of farmers can be further refined and the varieties ultimately evaluated and released through the official process and the seed made available through the formal sector. Understanding the maize production constraints, particularly *Striga* damage, varietal preferences and farmers' methods of managing this parasite could be useful in designing an effective breeding program that incorporates *Striga* resistance and improves other agronomic traits as well. The development of *Striga* resistant maize hybrids, will hopefully contribute to the food security of millions of inhabitants of the maize growing regions. Participatory approaches have been developed to tap the extensive knowledge of the farmers, investigating the production constraints and the farmers' preferences in the varieties they desire to grow. The overall objectives of this study were to determine the relative importance of *Striga* in relation to other maize production constraints and to lay the groundwork to develop breeding strategy for *Striga* resistant maize. The specific objectives were to: (i) assess farmers' perceptions and coping strategies of the *Striga* problem in maize production in Mali; (ii) identify preferred traits of farmers in maize varieties, (iii) determine maize production constraints besides *Striga hermonthica*; and (iv) assess the potential for breeding new maize hybrids with *Striga* resistance and other important agronomic traits.

Materials and methods

Study areas

Focus group discussions and individual interviews were conducted in Bancoumana and Kolokani, two districts of Koulikoro region (Figure 1). The convenience sampling approach (Marshall, 1996) was used to select the two zones because they are located in Mali's major *Striga hermonthica* infested zones. The two zones are located in the same agro-ecological zone (Sudan Savannah) and the annual rainfall is about 700-1000 mm Bancoumana is small city of Koulikoro Region of Mali. Located in the South-Western zone, the city lies in 13° 11'18''North and 8° 16'0'' West and 392 m altitude. In this locality, farmers are accessible and their collaboration level is good. Also the site is not too dry or too wet. Maize is produced in a poly-cropping system under irrigation mostly for green ear consumption. Kolokani is located in West-Centre of Koulikoro in central Mali. The North of Kolokani is dry; it is part of the Sahelian land suited for livestock. It runs along the interface of the wetter Sudan zone to the South. It belongs to the semi-arid Sahelian zone. Its geographic coordinates are 13° 35'27''North and 8° 02'03'' West and 305 m altitude.

Sampling procedures and conduct of study

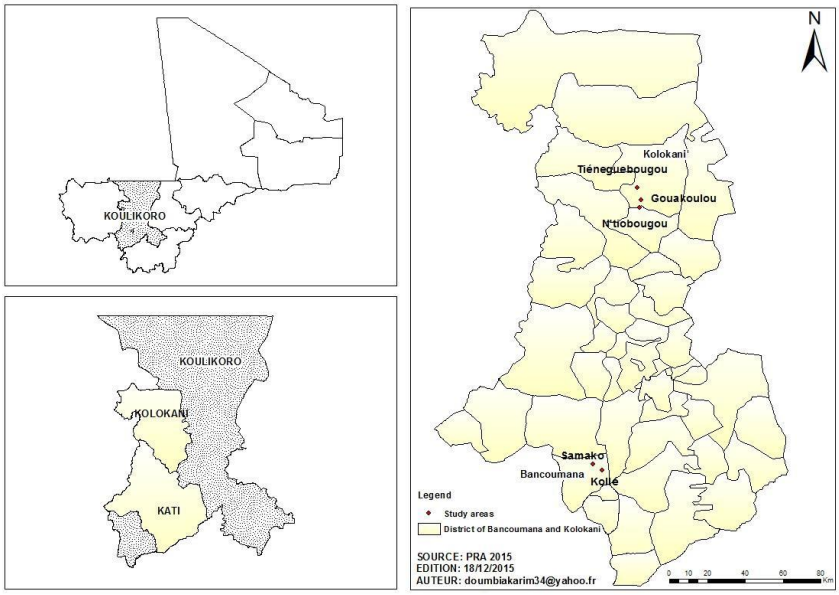
Focus group discussions were conducted in the two districts with 180 farmers suggested by extension officer. The villages were selected based on the level of *Striga* infestation and number of maize growers. One focus group discussion was conducted per district. The organization and information about the group discussion were done by Extension Agricultural Officers together with the chief of the village and the leaders of different village associations. The discussions were conducted separately with 24 small-scale farmers including 12 men and 12 women. A semi-structured questionnaire was prepared to investigate the nature and extent of problems in the region among the maize growing farmer and to get more information on various subjects including varietal preferences.

Data collected included size of farm land, the major crops grown, the production and the respective areas cultivated for each crop. Also information on the importance of maize yields, purposes for which maize is grown, different maize varieties grown, source of seed and preferred traits in maize varieties. Furthermore, data were collected on the major constraints affecting maize production and the coping methods, with special emphasis on *Striga* incidence and effects. Identification of *Striga hermonthica* symptoms was enhanced by using posters of infected plants of maize, sorghum, pearl millet and cowpea. This was done to show farmers *Striga* damage symptoms on cereal plants in general and maize in particular.

Data analysis

The socio-economic data including demography, farm size and major crops grown were recorded in Microsoft Excel and then imported into Statistical Package for the Social Sciences (SPSS) version 20. Data were coded and analyzed using nonparametric statistics and summarized into averages, frequencies or percentages.

Figure 1: Map of Mali showing sites where PRA was conducted



Results and discussion

Demographic characterization of selected farmers

Kolokani Cercle is home to primarily Bambara farmers. Kolokani Cercle in Mali is an administrative subdivision of the Koulikoro Region. Across Bancoumana and Kolokani districts, female and male farmers represented 2% and 98%, respectively, with ages ranging between 20 - 40 years. Over 70% of the maize growers were illiterate. The highest level of education was in Gouakoulou village.

Twenty two percent of respondents were between 18 -35 years old. Most (96.66%) of the maize growers were married and had more than one wife (polygamous). The average family size was almost the same with 21 persons per family. Farmers indicated that children are an important component of the farm's work force; hence large families weres necessary for increased farm sizes and production.

Maize varieties grown by the farmers

The majority of maize varieties grown by farmers are early (90 days) and intermediate (100 days) maturity which are suited to the growing season. According to farmers in Bancoumana, this preference for local varieties is based on the cheapest seed source, adaptation to the environment and food quality (taste). This finding agrees with Mann *et. al*., 1983, who reported that farmers select sorghum based on desirability for human consumption and adaptation to their environments. Most of the maize varieties grown are local landraces and open pollinated varieties (OPV). The major weaknesses of the local landraces are their relatively low yield, susceptibility to Striga and drought. The low maize yield is mostly due to susceptibility to biotic and abiotic stresses and over dependence on home saved-seeds for planting. Most of the maize grown by the farmers is highly susceptible to *Striga* (%). The average yield of the maize varieties grown ranges from 1. 4 to 1.6 t/ha (Table 1). The low yield of local varieties and their susceptibility to *Striga* justify interventions towards enhancing their productivity and resistance.

Table 1: Maize varieties grown in the two districts

Maize varieties	Types of varieties		Grain yield (t/ha)
American Kaba	-	Improved	3
Boni	Local	-	2
Bouaba	Local	-	1.2
Burkina	Local	-	1.5
Chetiokini	Local	-	1.5
Dembagnuma	-	Improved	3
Djolibaka	Local	-	1.5
Doudoni	Local	-	2
Flakaba	Local	-	2
Jorobana	Local	-	2
Kaba	Local	-	1.5
Kabadjema	Local	-	1.6
Kabasiteri	Local	-	2
Kabawoule	Local	-	1.5
Nieleni	Local	-	1.6
Sotubaka	-	Improved	4
Tiebleni	Local	-	1.5
Zanguereni	Local	-	1.4
Zeguereba	Local	-	1
Zeguerebleni	Local	-	1

Maize varieties uses in the two districts

In Bancoumana district, farmers said that maize plays an important role in food security. Farmers in Kolokani listed three main uses of maize; consumption, cash and fodder. According to farmers in Kolokani, maize is very important for consumption because of its multiple uses as vegetable, grain and its

Tieblenke and Zanguereni are listed in the West Africa Regional catalogue of species and varieties, 2016. These maize varieties are marketed in Mali (Abdoulaye *et. al*., 2012). Some varieties such as Burkina and American Kaba were introduced from other countries in West Africa and elswhere and then their names

were changed. Seeds are multiplied and sold by existing Seed companies in Mali to maintain their purity. Other varieties including Kabawoule, meaning yellow maize, kabasiteri (extra early maize variety) and Flakaba are the same local variety with several names. Cluster analysis could be conducted to show the relationship among them. Maize is a major staple food crop grown (Kamara *et. al*., 2006) and farmers constitute the basic food producers (Abdoulaye *et. al*., 2012). The low yield of maize varieties grown is often not enough for consumption and selling (Table 1). In Mali, maize markets have expanded and there are poultry producers, agro industries and export (Diallo, 2011). Research to develop high yielding maize varieties could reduce the deficit of maize.

Maize production constraints

Another objective of the present study was to identify the different production constrains among maize growing farmers farmers. Maize production constraints were identified and ranked using pairwise ranking method (Tables 2 and 3). In Bancoumana, the ranking of maize production constraints varied from women to men farmers. Male farmers indicated that high cost of inputs was the major constraint followed by low soil fertility and *Striga.* Major constraints to maize production for women were low soil fertility followed by lack of fields, high cost of fertilizer and lack of agricultural equipment.

Men and women ranked constraints differently although low soil fertility and high cost of inputs were very important for both. *Striga hermonthica* infestation was ranked second and sixth by men and women, respectively. In Kolokani district, the major constraints for men were low soil fertility followed by drought, high cost of farm inputs and *Striga*. Women indicated that their top three constraints were lack of fields, lack of equipment and low soil fertility. Hence, it can be anticipated that among men and women the constrains are different among maize producing farmers.

Due to lack of equipment, their fields are ploughed last and they miss the best sowing time because men own all the farm equipment. However, all farmers pointed out lack of agricultural equipment as other obstacle to maize production in Bancoumana and Kolokani Districts. This cannot be solved by breeding but requires intervention by other partners involved in rural development. Our study showed that fertilizer cost are a major constraint for maize production. Most of the farmers indicate that they do not grow hybrids because the cost of seed and other inputs such as fertilizers which are expensive (Abdoulaye *et. al.*, 2012). Production of hybrids is associated with the application of fertilizer and use of improved seed (Echekwu, 2000).

Farmers in the two districts grow cereal crops such as maize, sorghum and pearl millet. Continuous cropping of susceptible varieties has increased the level of *Striga* infestation and declining soil fertility. Low soil fertility has been identified one of the top three maize production constraints. The cereal crops grown by farmers are attacked by *Striga hermonthica*. Therefore, its damage was classified among the top three crop production constraints in the studied Districts. This is in agreement with Coulibaly, (2013) and Sissoko (2016) who reported that *Striga* is one of the major cereal production constraints in maize growing areas in Mali.

Striga infestation is aggravated by the use of susceptible varieties, poor quality seed from previous harvest carrying *Striga* seed, unclean hoes for ploughing and weeding which move from infested fields to non-infested fields. Several studies have shown that *Striga* and low soil fertility act together (Lakoge *et. al*., 1991; Weber *et. al*., 1995; Ransom, 1999; Debrah *et. al*., 1998). With the presence of these threats, farmers may not be able to feed themselves from one season to the next.

Table 2: Pairwise ranking of constraints affecting maize production in Bancoumana

Traits	Men		Women	
	Score	Rank	Score	Rank
High cost of fertilizer	4	1	2	3
Low soil fertility	3	2	5	1
Striga hermonthica	3	2	0	6
Lack of equipment	1	4	1	4
Lack of field	0	6	6	2
Herbicide	0	6	3	6

Table 3: Pairwise ranking of constraints affecting maize production in Kolokani

Traits	Men		Women	
	Score	Rank	Score	Rank
Low soil fertility	4	1	4	2
Drought	3	2	1	5
Insuffisance of equipment	1	5	5	3
Striga hermonthica	2	3	0	6
High cost of input	2	3	2	4
Lack of field	0	6	0	1

Farmers' perceptions of the parasitic weed

Striga hermonthica

The parasitic angiosperm, Striga, is an obligate root parasite which infects cereal and legume crops in sub-Saharan Africa, often causing yield losses in excess of 50 %. In Bancoumana district, a greater percentage (80 %) of responding farmers in Samako, Bally and Kolle considered *Striga* destructive to crops while 70 % of the responding farmers in Kolokani linked *Striga* to low soil fertility. Predominantly sandy loam soils, especially in Kolokani, favour survival of *Striga hermonthica*. The perceptions of farmers in Bancoumana and Kolokani districts about the traits related to *Striga hermonthica* infestation on maize are given in Table 4. The list of traits used in the analysis in each village was constructed by the particular village's corresponding preferences. In Bancoumana village, there were three traits whilst in Kolokani village, there were four traits. Low soil fertility, lack of external inputs and soil aging were common across the two districts. 15.8% of the farmers associate yield losses with the use of susceptible maize varieties.

Table 4: Perception about factors related to *Striga* infestation

District	Factors	Rank
Bancoumana	Low soil fertility	1
	Soil aging	2
	Low or no external input	3
Kolokani	Low soil fertility	1
	Soil aging	2
	Low or no external input	3
	Drought	4

Preferred traits in maize varietal development

Farmers mostly grow local landraces which are chosen for their taste and maturity to match the length of the growing season. Farmers think high yield and good taste are the two most important traits. Grain colour, big cobs and earliness rank third (Table 5). In both Bancoumana and Kolokani villages, men and women farmers concurred in their rankings for high yielding, early maturity, *Striga* resistance, drought tolerance and large kernel size, in order of importance. The yellow endosperm is preferred by the majority of the farmers. The yellow endosperm grain was believed to be more delicious than the white endosperm. Farmers explained that earliness was important because it guarantees a higher chance of harvest and insures early provision of food for households. Farmers in both districts attribute higher price for large kernels. As for the seed type, easy shelling and soft grains with high palatability were important.

A small number (1.7%) of farmers from Bancoumana reported that they never wished to experience a varietal change because they have been told that all new varieties could be genetically modified organism (GMO). They believe that new cultivars come with natural genes which may change the genetic background of their current varieties. Such farmers need training, which should be conducted by plant breeders, agricultural scientists, extension officers and other rural rural development partners to adopt new cultivars with high yielding potential.

The top three preference criteria used by farmers during varietal selection does not vary from one District to another.

Most of the major traits preferred are connected to yield. None of the maize growing zones in the country are spared from *Striga hermonthica* damage, but there are varying levels of infestation. Among the three criteria reported here, two were reported by Defoer *et. al*., 1997 and Buah *et. al*., 2013 namely yield potential and earliness. According to farmers, early maturing maize varieties ensure food availability during the hunger period before the other crops like sorghum can be harvested, therefore increasing the productivity and food supply.

Farmers are involved in the production of maize and several other crops to ensure food security. There are breeding opportunities for increased yields in the local maize varieties. Farmers grow mostly early and intermediate maturing maize to cope with declining soil fertility and unpredictable climatic conditions. This is consistent with previous reports that farmers would prefer early cultivars to provide food when stores become depleted and command higher market price when sold. In southern Africa, the “mother and baby” trial design was developed in collaborative plant breeding approaches, and the results showed the latter have an advantage over traditional approaches in selecting and deploying more appropriate varieties (Bänziger and de Meyer, 2002)

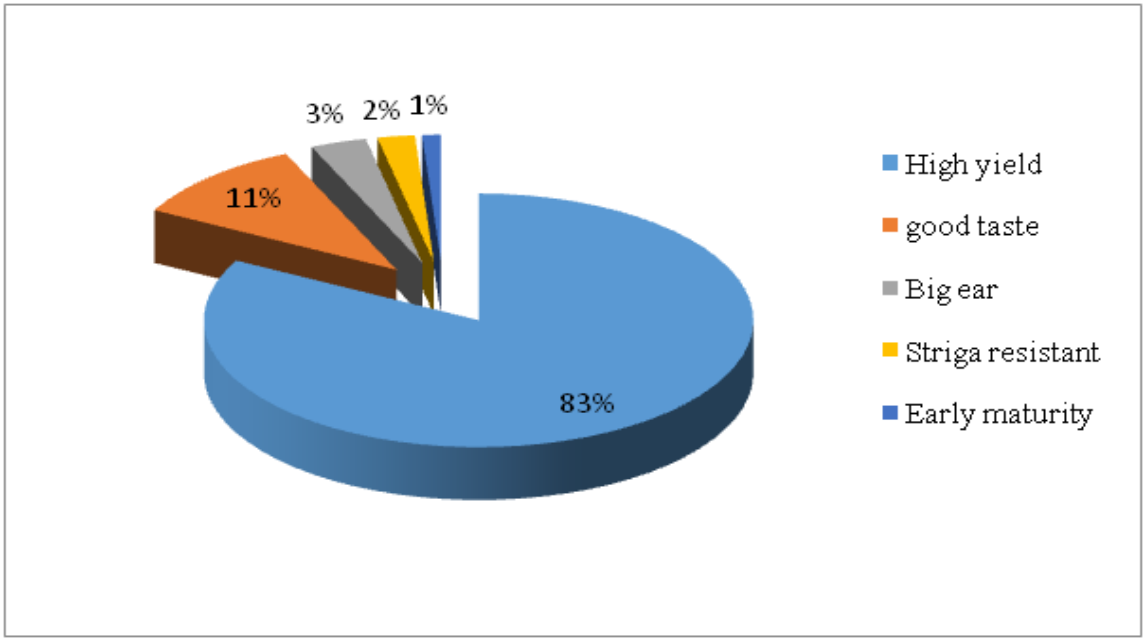
Table 5: Pairwise ranking of important maize attributes in Bancoumana and Kolokani

Criteria	Bancoumana		Kolokani	
	Score	Rank	Score	Rank
High yield	4	1	4	1
Earliness to maturity	2	3	2	2
Good taste	3	2	2	2
Seed colour	1	4	1	4
Big cob	1	4	1	4

Farmers' coping strategies and breeding opportunities

Farmer's local practices are meant to reduce the damage from *Striga* and increase maize yield. To overcome the lack of fertilizers, farmers use several strategies. These include crop rotation, intercropping (cowpea), groundnut, and bambara groundnut and other soil conservation practices as alternatives to inorganic fertilizers. In the two districts, soybeans were not grown. The choice of soybean is supported by Schulz *et. al*., 2003 who suggested the promotion of high yielding crop. Kamara *et. al*., 2008 and Ellis-Jones *et. al*., 2004 found that soybean used to produce nitrogen could subsequently increase maize yield. Farmers' methods for managing soil fertility included the application of animal manure, soil conservation practices and fallow.. In this study *Striga* control measures did not use *Striga* resistant or tolerant maize because most farmers did not know about *Striga* resistant maize. There is opportunity to introduce *Striga* resistant or tolerant maize in these two districts. For this finding corroborate with Safiatou *et. al.*, 2019 who studied heterosis for *Striga* resistance in maize testcrosses in Mali to identify new hybrids resistant to the *Striga*. Several maize breeding opportunities were identified during the plenary sessions, including the development of maize resistant to *Striga*, high grain yield, early maturity, good taste and big cobs (Fig. 2). The identification of high yielding varieties is in agreement with Fufa *et al.*, 2010 in which farmers selected the highest yielding varieties. Farmers' ranking of pest resistance as crucial in the breeding programme might have been exacerbated by their experience with *Striga* weeds, whose damage is easily noticeable. This finding agrees with Berner *et. al*., 1997 who reported that, in the West African savanna, *Striga* is a serious problem for cereal. Besides the aforementioned traits, farmers stressed their preference for large kernels, which they associate with increased seed weight and higher prices. Large kernel preference, big cob size and double ears were cited as the major reasons for liking hybrids. Rouging *Striga* plants before flowering will stop new *Striga* seed from being added to the existing seed in the soil (Emechebe *et. al*., 2004). This strategy, used by farmers in the two Districts revealed that farmers thought above ground damage due to Striga was more important than underground damage.

Fig 2: Breeding opportunities identified in Bancoumana and Kolokani Districts in Mali



Conclusions

Most of the farmers in Bancoumana and Kolokani Districts of Mali are illiterate. Crop production is important and constitutes a source of income for farmers. Local varieties are still very popular, indicating that there is room for the introduction of new varieties. Most of the crops are produced either for family consumption, for sale or for both purposes. Soil fertility and *Striga* infestation are linked together, so attacking the *Striga* problem alone will not lead to higher yield. It is important to also improve the declining soil fertility. There was no indication of high *Striga* resistance in any maize cultivar grown by farmers, which necessitates breeding for resistance.

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