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Participatory rural appraisal of sorghum anthracnose management in ten regions of Burkina Faso

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Abstract

Sorghum (*Sorghum bicolor* L. Moench), is a cereal crop that is commonly grown in Burkina Faso as a staple food crop. It is being grown by small and large scale farmers. However, the crop in farmers' fields yields less than 1t/ha. This is due to diverse constraints including the use of low yielding landraces, low use of fertilizers, abiotic and biotic stresses. Anthracnose is one of the most damaging sorghum diseases. Farmers' awareness of anthracnose is important to achieve a good control of the disease. The aim of the study was to assess farmers' knowledge on sorghum production constrains with peculiarity on sorghum anthracnose, disease management and their cultural practices. A participatory rural appraisal survey was done in the top ten producing regions of sorghum in Burkina Faso. Questionnaires and focus group discussions semi structured were implemented to collect data. A total of 265 farmers were interviewed. Most of farmers (71.3%) showed awareness of constrains to sorghum production. They shared that the biotic stresses were the main constraints in sorghum production. About 68% of farmers mentioned the presence of harmful insects during the plant growth stages. Striga was mentioned as a major weed concern for 62.8% of the farmers. Also, less than 20% of them acknowledged that sorghum anthracnose is a concern for the crop productivity. Farmers preferred sorghum with white grains and good taste for their dishes as "tô" and "dolo". They were unanimous on that yield is the important trait that the breeder should focus in each agro ecological zones of sorghum production.

Keywords: Sorghum, farmers, rural appraisal, preferences, farmers' seeds, anthracnose, Burkina Faso.

Introduction

Each year, agriculture sector contributes to at least thirty percent of the gross domestic products of Burkina Faso (Plecher, 2019). Agricultural activities occupy ninety percent (90%) of the population. Burkina Faso has three distinct agro ecological zones based on rainfall distributions. The country has a tropical climate that favours the development of the agricultural activities (cropping, and animal rearing). Temperatures are suitable for growing various types of crops such as: roots and tubers (sweet potatoes, cassava, yam, and cocoyam),

legumes (cowpeas, peas, beans, soya), oleaginous crops (sesame, cotton, bambara groundnut), and horticultural crops (tomatoes, eggplants, cabbages, onion, okra). Farming is mainly done during the raining season which lasts from three to four months. In Burkina Faso, sorghum is the top cereal grown in all the thirteen regions of the country. According to the report of the "Centre d'étude et de Conseil en Development" (CEFCOD), in 2013, 84.2% of sorghum growers are from the "Centre" region followed by the Centre-Sud and the Centre-Est region, Moreover, 45% of cultivated lands are allocated to sorghum. However, during the last five years, the area available for the crop production decreased due to the growing demography of the Country (FAOSTAT, 2015). Most the sorghum varieties grown in Burkina Faso, belongs to local sorghum varieties named farmers' varieties (Barro-Kondombo 2010; Vom Brocke et al. 2014; Barro- Kondombo et al., 2016).

Farmers choices of sorghum varieties for production depend on grain colour, texture of the endosperm (waxy - type, non-waxy), plant growth cycle and the taste for the specific food made from the grains. The crop growth cycle varies from 70 for the early ones to 130 days for the late ones. Nowadays, due to the recurrent shortage of rainfalls, farmers are seeking to grow early maturing sorghum varieties. This is challenging with sorghum as many local varieties have long duration to maturity because most of their sensitivity to photoperiod (vom Brocke et al. 2010).

The agriculture research center INERA (Institute of Environmental and Researches in Agriculture) since 1996, have been developing several improved varieties for sorghum as well as all types of crops. This is meant to boost sorghum productivity in the country. Thus, several improved sorghum varieties have been released. However the adoptions of these varieties were not high. The reasons may be due to several factors such as seed availability and preferences. That may limit farmer's adoption rate of new varieties (Witcombe et al., 2005, Dalton and Zereyesus 2013). Also, farmer need to be involved in the cultivar development process, farmer's perception of the technology may be biased during their decision making whether to adopt it (Wubeneh 2003). Therefore, adoption of improved varieties is highly dependent on the way it is proposed to farmers and consumers, its affordability, and its perception by farmers. The latter is based on agronomic (yield and resistance to stress) and end-uses (meals, tô, couscous, biscuits, cakes, and beverages such as dolo, zoom- koom, and wine) criteria, which should guide the breeder in the process of crop improvement (Vom Brocke et al. 2010). That is, the collaboration between farmers and the breeder should begin at an early stage of cultivar development through to varietal testing in farmers' fields (Weltzien 2014, Mengistu et al. 2019).

Even though sorghum is the top crop in cultivated area and production in Burkina Faso, the demand to sustain food security is very high and the crop yields are very low (1.1t/ha) (FAO 2015). High-yielding and resilient sorghum varieties are needed in Burkina Faso, to improve productivity under variable biotic and abiotic constraints. The breeding objectives, even though applied to all agronomic traits were not applied to breed for specific biotic constraints such as breeding for disease resistance, especially anthracnose disease that greatly affects grain yield and quality. The effects of the disease on sorghum have already been known since 1997 by several plants pathologists in Burkina Faso. The anthracnose disease is common in the entire sorghum production zone. It appears yearly and at the late stage of development of the crop. This makes its control difficult by the chemicals. (Kaboré et al., 2001, Neya et al., 2002, Zida et al., 2008). Several cultural practices have been used to reduce the incidence of the disease. The most sustainable and effective method to reduce damage is to breed sorghum with high levels of resistance to anthracnose. In the process of breeding for anthracnose resistant sorghum varieties, local farmers' participation should help design a breeding approach for the assessment of their preferences in sorghum improvement. The main objective of this PRA was to assess farmers' awareness and knowledges in sorghum production constraints and their expectations for the improvement of the preferred agronomic traits. The specific objectives of the study were to: - assess the impact of anthracnose on sorghum in farmers' fields, and - acquire farmers' knowledge about anthracnose disease management.

Materials and Methods

Study areas

The PRA survey was centered on the ten largest producing regions of sorghum in Burkina: Nineteen departments from the nine regions occupy the three agro ecological zones of the country. The locations selected for this PRA were grouped in the Table (1) and illustrated in the Figure (1).

Table 1: The participative rural areas surveyed in the ten most producing sorghum regions in Burkina Faso, 2013

N0	Regions	Locations
1	Boucle du Mouhoun	Nouna, Solenzo, and Dedougou
2	Centre	Kindi
3	Centre-Ouest	Komsilga Kombissiri
4	Centre-Sud	Sapouy and Leo
5	“Est	Fada and Gayeri
6	Centre-Est	Tenkodogo
7	Centre-nord	Toesse
8	Nord	Gourcy and Yako
9	Nord-Est	Zikieme, Bogande
10	Hauts Bassins	Samorogouan, Karangasso-vigue and Hounde

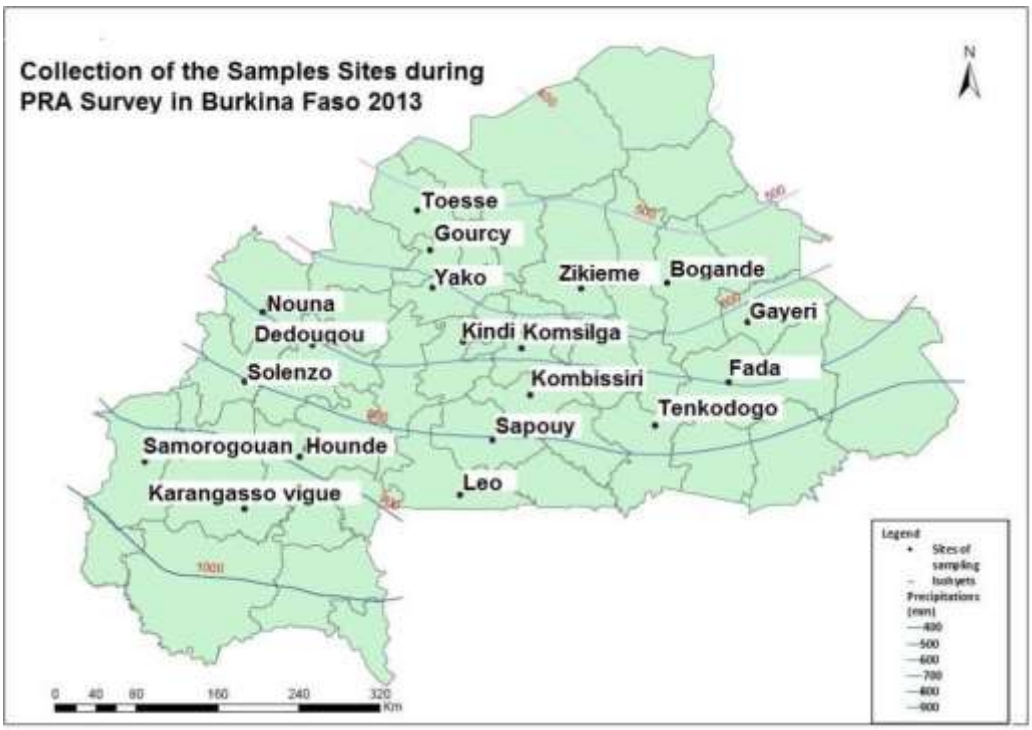

Figure 1: Study areas for the PRA (participatory rural appraisal) on farmers’ knowledge on sorghum production constraints

Sampling procedures

At each province, three villages were selected based on geographical distribution. In each selected village, sorghum growers were invited for a meeting and focus group discussion. Farmers were advised about the upcoming meeting with the research team, a week before the meeting. Three hundred farmers participated in the meeting with surveyors, including a researcher, the local extensions and a lead farmer. The two later were included as agents aware of cultural norms and habits of village farmers. Before starting the meeting, the team was introduced to the chief of the area to present the team and to seek permission to start the meeting with the group of 10 to15 farmers and the objectives of the meeting. Overall discussion was done followed by a focus group discussion. Finally, 10 to 15 farmers were interviewed using a semi structured questionnaire.

Methods of interaction

Several design tools were used. These tools are focus group discussions, semi-structured interviews with questionnaires, direct observations of techniques in fields, markets, storage facilities, processing units and triangulation of the information by multiple sources like secondary data from the agricultural officers and sorghum associations. Pairwise ranking of data was also used.

Data collection

Data were collected on farmers' cropping systems and on the socio-cultural aspects of sorghum. Data also were collected on the sources of the farmers' seeds, varietal preferences, planting and the crop management procedures, the source of seeds and postharvest management of the crop. Data were recorded on farmers' production constraints, their perceptions on sorghum grain quality, improved varieties, sorghum anthracnose and undesirable characters of sorghum. Farmers' perceptions on climate change were recorded as well as their inputs for better improvements of sorghum.

Data analysis

The questionnaire list was created with the software Sphinx Lexica (version4.5.0.26alyses were done using). Data analyses were done with Sphinx Lexica and SPSS (version 20) software. Analysis included the means variability, convergence and divergence of the famers' preferences.

Results

Sorghum production constraints

The total number of the people interviewed was 265 across the zones. Farmers considered drought as the major abiotic constraint that is recurrent each year during the rainy season. Among the biotic stresses, diseases (71.3%) were the main constraints in sorghum production. Over 68 % of farmers mentioned the presence of harmful insects (white flies, aphids, mealy bugs, armyworms, beetle) during the plant growth. Striga is a concern of 62.8% of the farmers and of 50.0% were concerned with grass hoppers Farmers reported that the plant growth (stage 2) is the most sensitive stage for pathogenic damages. They said as the plant grows tall with the development of the luxuriant canopy the pathogens become many. However, all four stages of the crop development are susceptible and affected by the biotic constraints (Table 2).

Table 2: Sorghum production constraints in relation to the crop growth stages

Stages of appearances	Percentages of General Constraints			
	Harmful insects	**Diseases**	**Weeds (Striga)**	**Grass hoppers**
Seedling Stage (Stage1)	20.9	8.7	5.7	25.8
Growth (Stage 2)	**68.2**	**71.3**	**62.8**	**50.0**
Flowering (Stage 3)	6.8	17.3	**29.1**	13.3
Grains Filling (Stage 4)	4.1	2.0	2.4	10.8
All stages	0.0	0.7	0.0	0.0

The most important biotic constraints are represented in Table 3. The mean value of anthracnose was 2.26, smuts 2.22, downy mildew and rust 1.46.

Table 3: Mean and ranking of biotic constraints of sorghum production in relation to sorghum growth stages

Constraints	Mean	Rank
Weeds: striga	2.28	1
Anthracnose	2.26	2
Loose and covered smuts	2.22	3
Nematodes	2.15	4
Grass hoppers	2.09	5
Armyworms	2.07	6
Downy mildew	2.02	7
Harmful insects	1.94	8
Rust	1.46	9

Farmers' perceptions on sorghum anthracnose

Farmers acknowledged that sorghum anthracnose is a concern to sorghum productivity. The literature indicated that the anthracnose disease is present in all regions. The proportion depended on the regions: Hauts-Bassins (10.3%), Centre-Nord (6.5), Nord (2.3%), East (1.9%), Centre Ouest (1.5) and Boucle du Mouhoun (1.5%), (Table 4).

Table 4: Proportion of farmers acknowledged the presence of anthracnose disease in their field during the PRA study's in Burkina Faso in 2013

Percentage of the presence of anthracnose disease				
Survey areas	**None observed (1)**	**Observed with no treats (2)**	**Fairly Observed (3)**	**Outbreak (4)**
Boucle du Mouhoun	7.3	0.0	0.0	1.5
Centre-Ouest	2.7	1.1	1.9	1.5
Centre Est	1.9	0.8	0.4	0.4
Centre Sud	14.9	13.0	10.3	0.0
Nord	**5.3**	**5.3**	0.4	**2.3**
Centre-Nord	**0.8**	**0.0**	0.4	**6.5**
Est	**3.8**	**2.3**	**1.5**	**1.9**
Hauts-bassins	**1.1**	**0.0**	**0.0**	**10.3**
centre	0.4	0.0	0.0	0.0
N valid				**262.0**
N missing				**3.0**
Mean				**21.9**
Total				**265.0**

Control methods

Few farmers (1%) make use of pesticides to control diseases during the plant development for all the regions. Many farmers (60%) rogued out diseased plants. Others used crop rotation to reduce disease pressure in their fields (9%). Some burnt diseased field after harvest and they used some traditional practices to prevent and discard diseases from their fields. Others (24%) do not apply any means of control (Table 5).

Table 5: Farmers' methods to control anthracnose disease in their field

Farmers' controls methods					
Survey Areas	**Total of Farmers**	**Crops rotation**	**Rogueing**	**Utilization of pesticides**	**Nothing**
Boucle du Mouhoun	9%	0%	5%	1%	3%
Centre-Ouest	8%	1%	6%	0%	1%
Est	10%	0%	7%	0%	3%
Centre-Nord	8%	1%	7%	0%	0%
Nord	**13%**	0%	**12%**	0%	1%
Hauts-bassins	11%	0%	10%	0%	1%
centre	0%	0%	0%	0%	0%
Centre Est	4%	0%	3%	0%	1%
Centre Sud	**37%**	7%	**16%**	0%	**14%**
Total	**100%**	**9%**	**66%**	**1%**	**24%**

Source of seed and conservation

Most of the farmers inherited from their parents their growing seeds (71%) , 13% obtained their seeds from their neighbours, 11% from their granaries, 4% from the market and 1% usually obtained their sorghum seeds from the government. The data also shows that 58% of farmers grew sorghum because they had been familiar to the crop since their childhood as sorghum growers and 33% of farmers grew sorghum for commercial purposes (Table 6).

Table 6: Proportion of farmers sorghum growth preferences in relation to the seeds sources, recorded during the PRA survey in Burkina Faso in 2013

Sources of Accessions link to the choice of the farmers	**TOTAL**	**Inheritance**	**For Market**	**Early mature**	**At least two**
Inheritance	**70%**	**47%**	**21%**	1%	1%
Granary	12%	4%	4%	2%	2%
market	4%	1%	3%	0%	0%
Gift from neighbours	**13%**	**6%**	**5%**	1%	1%
Government	1%	0%	1%	0%	0%
Total	**100%**	**58%**	**34%**	**4%**	**4%**

Farmers' perceptions on improved varieties

Many farmers (62%) were not aware of improved sorghum varieties. However, about 15% of the farmers interviewed were aware but they did not grow them. Farmers surveyed in the Centre South were not aware of improved varieties

of sorghum. Overall, 24% of the farmers used improved varieties. Farmers were saving their seeds from their harvest and were using them as source of planting material at each rainfall season (Table 7). From the varieties, Kapelga (a white grain color) variety was the most known and the most widely grown by farmers in all the regions (63%). The Sariasos (white grains color) varieties are known and grown by some farmers (27%). Irat 204 (white grains color) was the least grown by farmers (1%).

Table 7: Farmers' awareness and preferences on improved varieties of sorghum during the PRA survey in Burkina Faso in 2013

Studied areas	Total	Unknown	Aware but not used	Familiar and use
Boucle du Mouhoun	8%	6%	0%	2%
Centre-Ouest	8%	2%	4%	2%
Est	10%	6%	3%	1%
Centre-Nord	7%	3%	1%	3%
Nord	**13%**	1%	**5%**	**7%**
Hauts-bassins	**15%**	**8%**	2%	**5%**
centre	0%	0%	0%	0%
Centre Est	5%	4%	0%	1%
Centre Sud	**34%**	**31%**	0%	3%
Total	**100%**	**61%**	**15%**	**24%**

Farmers' perceptions on sorghum grain qualities

The survey revealed that 80% of farmers were more interested in white grain colour, 76.7% farmers preferred hard pericarp grains that produce good "tô", 14.6% of farmers preferred grain hardness that meant the grains that were not easily crumbled, and 8% taste for "dolo". The grain shapes, panicle threshability; the testa colour and the marketability were not very important (Figure 2). White grains colour was mostly preferred colour for "tô" and sweet beverages" zoum-koom" preparations, while the red grain color was mostly preferred for alcoholic beverages such as "dolo" preparation. The grains colour was an important criterion for farmers during the study.

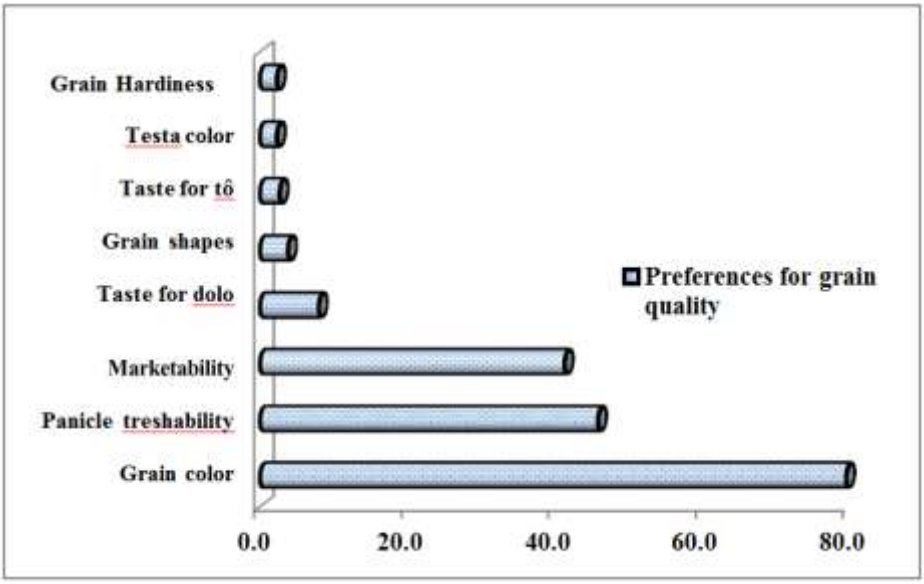

Figure 2: Farmers' preferences for grains qualities in Burkina Faso in 2013

The most important trait that all farmers agreed to be important was the variety must be high yielding, quantitatively (good panicle coverage) as well as qualitatively (tasty for food, beverages, palatability for feed and long conservation duration) (90, 9%), (Figure 3). For 80.7% of farmers, the variety must also be early maturing, followed by good storability (80%), drought resistant (13.9%), and good germination ability (13.4%).

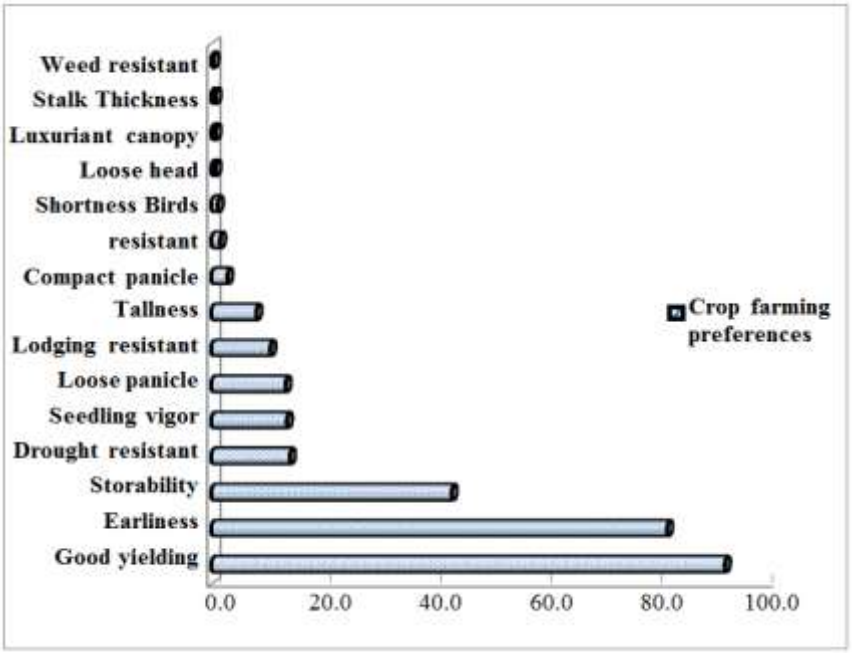

Figure 3: Farmer's agronomic trait preferences for sorghum variety in Burkina Faso in 2013

Farmer's inputs for improvement

According to farmers, research should focus on sorghum grain quantity and quality (95-95%), growth cycle (63-50%), disease resistance (42-40%), storage ability (29-40%), drought tolerance (11-15%), and marketability (20%, 15%); (Figure 4).

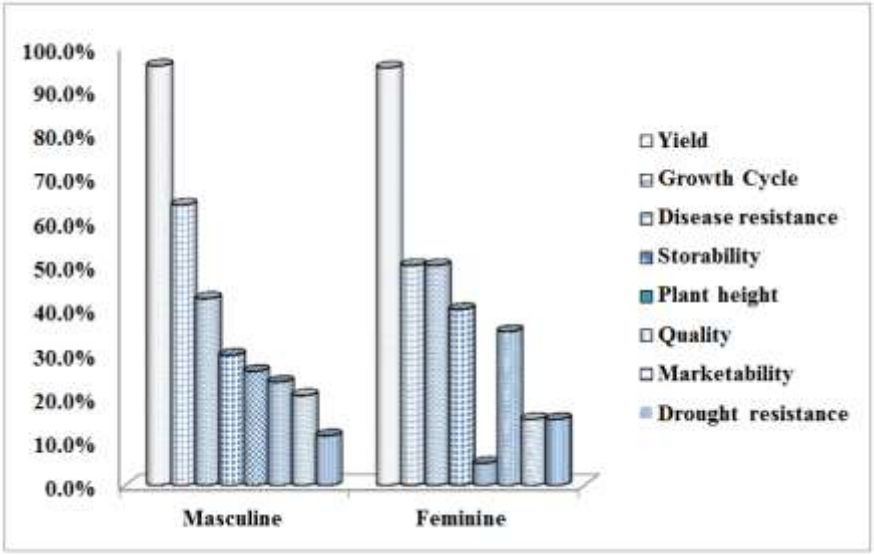

Figure 4: Proportion of farmers' expectations for sorghum improvement obtained during PRA study in Burkina Faso in 2013

Discussion

The study revealed that in the rural areas studied, the biotic constraints were the most damaging, 71.3% of farmers thought that diseases were the most injurious constraints followed by harmful insects 68.2% (armyworms, aphids, mealy bugs, mites, and thrips); weeds 62.8% with emphasis on *Striga hermontica* and 50% complained about the grasshoppers. Most of the constraints were prevalent during the growth stages of the plant. This is because damaging insects eat young leaves and stems which is harmful to the plant development (Peterson and Higley, 2000; Kaplan, et al., 2009). The most injurious disease caused by fungi is anthracnose. The disease is present almost every part of the country. The Hauts–bassins and Centre Nord regions were the hot spots of the disease. The disease was not a concern for farmers in the central region as they use seed treatment with chemicals before the seeds were sowed. The disease is also a concern in many countries around the world (Marthur et al., 2002, Sharma et al., 2015). Some countries have developed resistant varieties and there it is no more a concern (Wang et al., 2006, Erpelging, 2008, Perumal, 2009, Souza, 2013). For the control of the disease in their fields, farmers were removing of the diseased plants (66%). Less than 2% of farmers used chemicals to repel insects' pests, nematodes, and diseases. Most of farmers have not been trained to identify diseases. Thus, 24% of the farmers confirmed that they did nothing to control the disease establishment or spread. The low number of farmers trained by the extensions agents of the Ministry of Agriculture was applying the control methods. They knew the types of fungicides that could be used as well as the dosages to be used. For these Farmers seed treatment and diseases management were a must if they expected to get good yields of their crops. The usage of chemicals for seed treatment was not promoted by the extension agents however they encourage them to use natural plant extract. Several types of plants extracts from some medicinal plants such *as Eucalyptus globulus*, *Eclipta alba*, *Balanites aegyptiaca*, *Acacia nilotica*, *Khaya senegalensis* etc. were used as controls methods in seeds and plants protection (Karou et al., 2005, Tegegne et al., 2008, Satish et al., 2009, Zida, et al., 2011).

Farmers did not have any formal educational training (formal schools, local trainings in local language) but most of them were able to discuss issues on the sorghum production constraints, their knowledge and preferences. Farmers have great knowledge on the growth of the plant since they have been practicing sorghum growing for years. Some of them grew up growing sorghum. They are familiar with all the sorghum crops characteristics and constraints. Famers' knowledge on sorghum, has allowed some of them to harvest good quantities of seeds for their livelihoods. The cropping systems used by the farmers from all the agro-system where similar, 47% of farmers grow sorghum alone or intercropped with cowpeas (46%). The adoption of a particular cropping system is mainly due to the training received from the agricultural extension agents in sorghum crop management in the field. This corroborates the same findings of vom Brocke et al., (2010 and 2014). Farmers who had been trained, improved their cropping system by either growing improved seed or practicing homologues cropping practices such as; monoculture or mixed with cowpeas. Whereas the farmers whom did not receive any trainings were still growing the crops as they were cropping the plant based on their practices. Farmers grew often sorghum in association with maize or pearl millet. Furthermore, farmers trained on crop management are aware of the danger that non-suitable intercropping could increase the number of damaging insects (Khan, 2007) and increase the competition for nutriments which could affect the yield of the crops. The farmers who intercropped sorghum with other cereals (pearl millet, maize) and legumes (bambara groundnut) were concerned about the availability of the cultivatable lands. Farmers grew a mixture of sorghum varieties to avoid crop failure. Farmers that grow their local varieties inherited the seeds from their parents or collected directly from their fields, granaries, and neighbours. Few of the farmers relied on government seeds. Only one percent of farmers regularly ought improved seeds of sorghum from the ministry of agriculture and the agribusiness companies. Then the progeny yield potential crop yield potential will be reducing year after year if the farmer is using the same grains from his field as source of planting material. That will be due to the fact the farmers with carry along diseased or poor qualities that may not germinate after sowing. Most of the farmers (70%) were still using their landraces, because they were not aware of improved varieties (62%) and they were willing to grow improved varieties of sorghum that meet their preferences. Some of the improved sorghum varieties which met their needs were Kapelga (63%) and Sariaso (11, 14%) which were appreciated and cultivated by sorghum growers. Each farmer has preference criteria in the choice of which sorghum variety to grow, but they all ranked the yield as the top priority. About 91% of the farmers choose to grow a variety if it was high yielding (91%), early maturing (81%), and has good storability (42%). They also based selection on the grain qualities: as grain colour (79%), the palatability of foods obtained either with the floor or the whole grains (77%) and the grain hardiness (14.6%). Similar results were also reported by vom Brocke et al. (2010) during the participatory varietal selection and participatory plant breeding section with sorghum growers (men and women) who were asked to make choices on their preferred agronomic and grain quality traits on 53 segregating sorghum progenies (F3 and F4) lines. Farmers will not grow a variety which is low yielding (93%); inedible for food and beverage (83%), sensitive to disease (82%), short

straw (77%), and poor storable ability. Similar results were obtained with other participatory rural appraisal, participatory plant breeding and participatory varietal selection (Wubeneh 2003, vom Brocke et al. 2010, Deu et al. 2014, Dao et al. 2015, Ouedraogo et al. 2017).

Farmers are sources of knowledge for plant breeders as they have the cultural knowhow of the crops. Growers know differences among sorghum varieties that are suitable for a climatic zone. They know that sorghum with short cycle of development is suited to regions with short rainfall or less than three full month's duration. And sorghum with a long cycle of development suits regions with long rainfall period, which means more than three full months. Thus they suggested that breeders should breed for varieties that will be high yielding (95%), suitable growth cycle (69%), disease resistant (50%) and high storable ability (40%). Overall, farmers wished to have some varieties that perform well in each of their environments.

Conclusion

The survey generated information on the main constraints that had effects on sorghum production. Important abiotic, biotic and socio economic constraints were recorded from Farmers. Drought was the most important abiotic constraint during the plant growth and the seed setting. Important biotic constraints were weeds (striga), diseases (anthracnose, smuts), nematodes, insects (armyworms) and grasshoppers. Farmers' acknowledged the presence of the disease in their field. In the six regions surveyed farmers from the reported that their fields were much affected by anthracnose. Most of the farmers acknowledged rogueing out the diseased plants by anthracnose out their field when they were not many. In the case where they were many they did nothing. Farmers who had received training on the crop management on field crop were using cultural practices and seed treatment with the right fungicides before seeds sowing. Farmers' preferred agronomic traits were: plant height (8%), growth cycle (80, 7%), panicle size (13.1%), seeds germination (13.4%), panicle compactness (2.8%), panicle threshability (2.4%) etc.). They liked specific grains qualities: colour (79%), taste (76.7%), and storability (42.5%) were collected. It was obvious in all the six regions surveyed that sorghum was an important cereal crop in farmers' areas. Most of the farmers stated that any improved varieties must be high yielding, give good taste for "tô" taste.

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