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The choice and preference of sorghum value chain actors in Mali

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The production and adoption of sorghum-improved varieties are faced with biotic and abiotic stresses affecting both its utilization and marketability by different actors in the sorghum value chain. This study aims to understand why and how different social groups and value chain actors make decisions on the utilization of sorghum and how these decisions influence the choice and adoption of the sorghum cultivars introduced and promoted by the breeding programs. This study was conducted in Mali's Sudan and Savanna zones, wherein the different agroecological zones have differentiated production and utilization realities and traits demand. Mixed methods (surveys, focus group discussions, key informant interviews) combined with intersectional and value chain approaches were used for data collection and analysis. The data were collected from 836 respondents in 12 villages including 384 females (46%) and 452 males (54%) representing sorghum growers, processors, consumers, and traders. While the findings show gender-specific trait preferences, actors' traits choices revealed the gender dynamics in value chains in which the different roles, interests, and challenges of men and women influence their choices and adoption of sorghum cultivars. The results also revealed there is an increased opportunity for the sale of sorghum grains (38%); this may be explained by the continuous efforts made by research institutes to develop high-yield sorghum varieties and the evolving processing sector in Mali.

Key words: Sorghum, gender, traits preferences, breeding, Mali.

INTRODUCTION

Sorghum is one of the major staple crops in Mali, representing the most important cereal crop in terms of agricultural land used for its production (FAO, 2017). Sorghum provides food security and a source of household income for smallholder farmers in West and Central Africa (WCA). To improve the adoption rate of sorghum varieties, efforts have been made by international and national research institutes, farmer grassroot organisations, and Non-Governmental Organizations (NGOs) in Mali including the development of high yielding improved varieties (such as hybrid, open-pollinated and dual-purpose varieties) and providing technological packages (striga, parasite, disease control techniques, micro-dose, and post-harvest management techniques) to manage biotic and abiotic stresses at the farmer level. Despite these efforts, sorghum yield remains low (less than 1 t /ha (Dembele et al., 2021; Kanté et al., 2019) with the adoption of improved varieties at an average of 22% (Smale et al., 2018,164). The low adoption rate of improved varieties can be explained by

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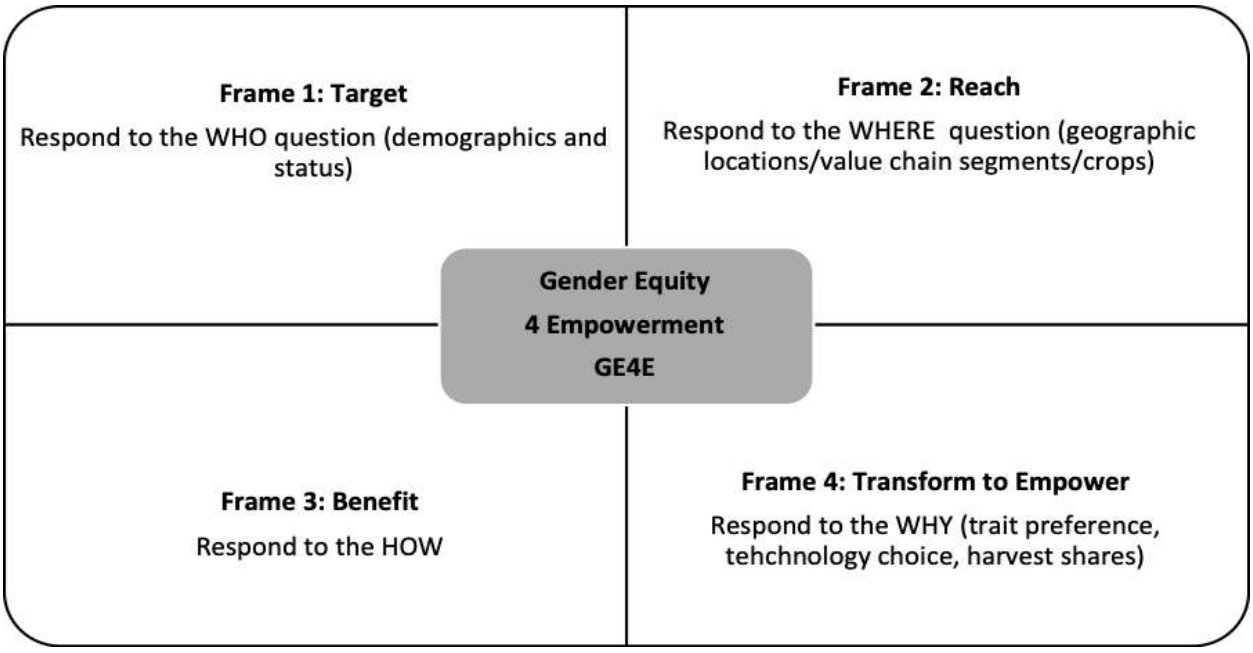

Figure 1. Integrating social and gender consideration into the agricultural technology development and deployment. Source: Author.

the lack of analysis that emphasized gender in differences in value chain actors' interests, roles traits choices, and gender relations in access to production resources including land, input, and basic farm tools and equipment in most communities in Mali. Previous studies have reported on differential trait preferences between men and women and also their complementarity in preferred trait demands due to their contrasting roles and responsibilities in household management (Diallo et al., 2018; Weltzien et al., 2019; Chambers et al., 1989; Ashby and Vivian, 2019). These studies on gender-differentiated information about trait preferences were not specifically designed for understanding gender-relations in context specific ways, but to show gender differences in production without analysing of the demands and the sociocultural context of production and utilization of the varieties by different value chain actors. One of the consequences of these studies is the production of a long list of desired preference traits by male and female farmers with little or consideration of the social context in which the actors make operates and decisions. Hence, assessing and understanding the choices and varietal preferences of the wider group of actors (farmers and processors and consumers, and traders) through a gender-responsive approach is necessary.

THEORETICAL AND CONCEPTUAL FRAMEWORK

Intersectionality denotes the interactivity of social identity structures like gender, class, age and race in fostering life experiences, of oppression privileges (Crenshaw, 1991, 1244; Gopaldas, 2013, 90). It refers the relationships among various modalities and dimensions of social relations (McCall, 2005). The implication of intersectionality at a micro-level of analysis is that every person in the society is situated at the intersection of several social identity structures. As a theoretical framework intersectionality has influenced current feminist conceptualizations of qualitative methodology, the development of new feminist approaches, social change, positionality, and situated knowledge (Simandan, 2019a, 2019b, 2020; Davis, 2014, 2020, 2021). Equally, intersectionality permits the study of diversity and differences among sexual categories, between the sexes and social groups. Thus, we developed a strategic framework, examine and respond to the crucial variable of inclusion considered cross-cutting component of value chain analysis in agricultural technology development and deployment (Figure 1).

CONCEPTUAL FRAMEWORK: FOUR FRAME MODELS FOR PROMOTING EQUITY AND INCLUSIVENESS

This conceptual framework is developed to systematically and intentionally ensure that major stakeholders are identified, targeted, and reached with the technologies, are engaged to contribute to decision-making that affect, benefit and empowers them. The importance of models 1 and 2 is to avoid assumption about who the beneficiaries

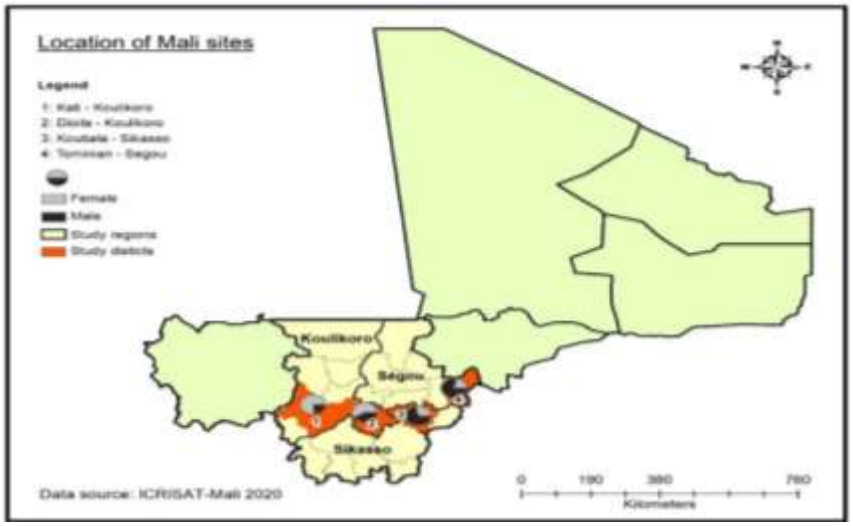

Figure 2. Map of Mali showing the four administrative districts of study sites.
Source: Author

are and or should be and to ensure no major social group is excluded. We identified the actors of the sorghum value chain in the different agro-ecologies by responding to the 'who and where' questions which aided examining how a person or group's social identify is being dis/advantaged. The social identity of value chain actors as the target beneficiaries includes indicators such as sex, age, the activity of the value chain actors, and the location or agroecology. Based on this analysis, the main disadvantages lie in the categorization of youth rather than sexes when it comes to resource allocation. Frame models 3 and 4 describes how and why the beneficiaries participate in and benefit from decisions on the choice of traits of sorghum varieties suitable for their activities and interest as end users. The frame models ensure that the major customers of the breeding products are part of the decision-making that leads to cultivar development. The co-design and creation process by the key stakeholder support the co-ownership and sustainability of the program and system. The overall outcome of gender transformative approach is to expand the capacity and opportunity for those that have been excluded to make deliberate and strategic choices by those who have been formerly deprive such opportunities in ways that do not simply reinforce but may dynamically challenge the structures of inequality in the society (Kabeer, 2017, 651). Gender and other social differences such as age, wealth, marital status, level of education, etc. have an enormous influence on the success of agricultural interventions and the choice of varietal traits. Although there is a growing awareness and recognition of including both men and women in participatory plant breeding process, intersectional analysis that looks at the influence of age, education and social status or wealth of men and women in the different segments of the value chain has not been considered in most studies. To bridge this gap and present a broader analysis and understanding of varietal trait preferences and choices, the major social categories of respondents are disaggregated to understand and show whether there is variance or not independently of sex categories and to understand how intersecting social markers and inequalities affect the most marginalized groups (such as, women and youths) (Klugman et al., 2014; Yuval-Davis, 2006). The examination of the ways in which non-technical features of local knowledge, that is, social and cultural factors, and gender norms and roles of specific value chain actors, are linked to the choices and preferences of end-users may determine the degree of acceptance or rejection of the breeding products.

METHODOLOGY

Study locations

The study was conducted in three regions consisting of Koulikoro, Segou, and Sikasso which are located in Western, Central and Southern Mali, within the Sudan and Savanna zones of Mali (700-1200 mm) (Figure 2). These regions are the most important sorghum production areas in Mali. The Participatory Plant Breeding (PPB) programmes of the national and international research institutes operated in the three regions by developing and testing sorghum varieties based on the agro-ecologies and farming systems. The region of Sikasso lies in the humid tropical agro-ecological zone while the regions of Koulikoro and Segou are located in the semi-arid agro-ecological zone of Mali. The three regions have a land area of 225 221 km^2 with a population of 7,403,636 persons in 2009, or 50.95% national population (National Population Census, 2009). These regions were selected because of the presence of sorghum breeding program activities such as on-farm trials and demonstration plots with farmer organizations for 20 years. The choice of the villages was mainly determined by

presence of seed production activities, availability of improved seed varieties locally, participation of farmers in breeding activities and the presence of processing or marketing activities. One of the features of the three regions is the patriarchal social organization and the importance of rainfed cereals like sorghum, millet and maize in the diet of the population. Whereas women represent 50.4 percent of the population, women and young people have limited access to agricultural lands, inputs (certified seeds and fertilizers), agricultural equipment, and participate less in agricultural trainings and innovations because of the rigid norms governing household assets and the male-based and patriarchal structure of agricultural production units. Under the regions, the districts and villages were selected based on the significance of sorghum production in the livelihoods of sorghum value chain actors. The target group for this study are the sorghum value chain actors represented in the consumption, trade or grain marketing, processing and production segments. Although the production, marketing and consumption segments seems to be well developed, medium to large scale processing is still underdeveloped in Mali.

Sampling and data collection

The study applied a mixed method consisting of both qualitative and quantitative tools for gathering study data. The total sample size from individual surveys, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) is 836 respondents comprising 452 males (54%) and 384 women (46%). Qualitative data were collected through FGDs and KIIs from 224 value chain actors across 12 villages. Discussion guides were designed for the FGDs and KIIs. In each selected village, at least 8 women only and 8 men only FGDs and 1 mixed FGD were conducted. The quantitative data was collected by administering a survey questionnaire with the use Survey CTO data collection tool by eight trained enumerators to a sample of 612 sorghum value chain actors from each of the three survey regions. These are individuals engaged in the production, consumption, trade, and processing of sorghum across the selected regions within the selected communities from which at least fifty (50) respondents were randomly selected for the study. The respondents were sorghum growers, processors, grain marketers, or consumers. The study was conducted in the 2019 and 2020 cropping season following a multi-stage sampling approach. Reconnaissance survey was first organized with farmer organizations' representatives and sorghum breeders to identify and select survey locations, sorghum varieties and the characteristics to be evaluated. Secondly, three administrative regions including Koulikoro, Segou, and Sikasso were purposively selected (Figure 2). The FGD sessions were recorded, and the information obtained was transcribed and coded to capture the various thematic areas of the study guide and analysed through establishing the categories and themes, relationships/patterns and conclusions drawn in line with the study objectives; while descriptive analysis using Statistical Package for Social Sciences (SPSS) and Wilcoxon ranking method were used to analyse quantitative data. A Wilcoxon signed ranks test which is a non-parametric statistical procedure was used to test for statistical significance, for instance, between male and female ratings of sorghum trait attributes (Bellon, 2002, 71).

Ethical precautions

The surveys and data processing were subject to a rigorous ethical procedure ranging from seeking community consent, individual consent, to the anonymization of respondents' personal data and identities during data processing and analysis. Community consents were sought and obtained from community leaders and extension agents before the survey began, during which the objectives and benefits of the study to the farming communities and value chain actors was explained. The interviewers and community leaders explained the objectives of the study and the importance of their participation at the beginning of the surveys to obtain individual consent without coercion or pressure on the potential respondents.

RESULTS AND DISCUSSION

This section describes the results and discussions of each analysed data including the demographic characteristics of the respondents, production factors and constraints, and value chain actors' traits of preference. Value Chain actors are the people at each link along the chain involved in activities required to move a product from the farm to the consumer (Chidiebere-Mark, 2018). The value chain is male and female actors involved in producing, processing, marketing, and consuming the sorghum.

Socioeconomic characteristics of respondents

Table 1 presents the socioeconomic characteristics of the sampled respondents from the study regions**.** The average age of the respondents is 42, and the average age of female and male respondents are 39 years and 47 years respectively. Thirty six percent (36%) of respondents were heads of household, among whom 64% are men and only 8% are female household heads. While 53% of respondents did not receive any formal education, there are disproportionally more women (63%) without education compared to men (43%). Out of those that attended primary education, the percentage of men (21%) is higher than that of women (14%). However, 13% of the respondents have received adult education trainings, of which 17% of men and only 7% are women. Although most of the respondents are not educated, education is significantly and positively associated with most of the sustainable agricultural practices (Manda et al., 2016) and enables quick adoption of new technologies (Enete and Igbokwe, 2009; Smale et al., 2018; Uaiene et al., 2009; Manda et al., 2020). In most of Malian agriculture innovation settings, it is generally the (male) young graduates who conduct the tests and demonstrations and thus become community links between their associations, the villages, the world of development and research because of their ease mobility, human capital (writing and accountancy literacy; group management skills) and their soft skills (open-mindedness, curiosity, and tendency to try new things and to challenge or question old practices) in the management of social, public relations and in the translation of techniques into practices (Sissoko et al., 2019). The participation of youth graduates in breeding activities is also seen as a guarantee of adherence by other users of the agricultural technologies promoted in the village. About 37% of respondents are aged from 15

Table 1. Socioeconomic information of surveyed respondents.

Characteristics	Male (n=328)	Female (n=284)	Average (n=612)
Age (years)	47	39	43
Share of youth [15-35 years] sample	12.74	24.67	37.42
Share of older adult [36 and above] sample	40.85	21.73	62.58
Household headship (%)	64	8	36
Marital status			
Married (%)	97	95	96
Single (%)	3	1	2
Divorced (%)	0	4	2
Widow/Widower (%)	0	0	0
Education			
No formal education (%)	44	63	53
Primary education (%)	21	14	17
Secondary education (%)	7	7	7
Tertiary (%)	7	3	5
Adult education (%)	17	9	13
Koranic education (%)	6	4	5
Others (%)	1	1	1
Sorghum utilizations			
Home consumption (%)	93	74	83
Market (%)	39	37	38
Processing (%)	2	36	19
Seed (%)	3		2
Animal feeding (%)	1	1	1

Source: Author

to 35 years while respondents aged from 36 years and above represent about 63% of the sample. Table 1 shows that the study targeted more female youth respondents (about 25%) than male youth respondents (about 13%). While we have applied the African Union's definition of youth (15-35 years)[1], this youth definition based on age range (African Union 2006) does not fit the social and cultural realities of youth in the areas where our study was carried out. It is in these societies where one can find a young man of 25 years polygamous with two or even three wives. The number of wives is considered as the sign of prestige and social achievement. These are societies where people marry very early and the youth period is being compressed because of early marriage. Early marriages are encouraged to cope with the shortage of agricultural labour, to keep young people on the ground, and to prevent premature pregnancies of girls. This is why we note in Table 1 that 96% of the respondents are married and only 2% are single. By deduction, we can state that the real young people in this study, based on the social praxis we referred above, constitute only 2% of the sample. This was confirmed to us during a focus group by a participant:

"*Here, you can be considering adult once you get married. Among us here, there are no young people; we are all married and heads of households. If you want young people, unless you find bilakoro (uncircumcised people) behind the goats*" (Young male participant in FGD).

Respondents' involvement in sorghum value chain nodes

Table 2 shows that about 56% of respondents are in the production node (farmers) comprising 78%men and 32%women. While about 23% of the respondents are considered as processors, a higher percentage (43%) of the processors is women with only 2% men. The high percentage of women in the processing is explained by the fact that women use traditional processing activities as income generation strategies and because processing of crop produce into secondary products are women-based activities. Those that are involved in grain trade are 6% among whom 8% are men and 3% women. Table

[1] Defining youth on the basis of numerical age, although contextual, seemed to be the most convenient way to analyze the quantitative data.

Table 2. Involvement in sorghum value chain segments.

Segments	Male (n=328)	Female (n=284)	Male youth (n=78)	Adult men (n=250)	Female youth (n=151)	Adult women (n=133)	Youth (n=229)	Average (n=612)
Production (%)	78	34	19	59	15	53	34	56
Consumption (%)	13	20	2	11	13	7	15	16.5
Grain trade (%)	8	3	3	5	2	1	5	5.5
Processing (%)	2	43	0.00	2	23	20	23	22.5

Source: Author

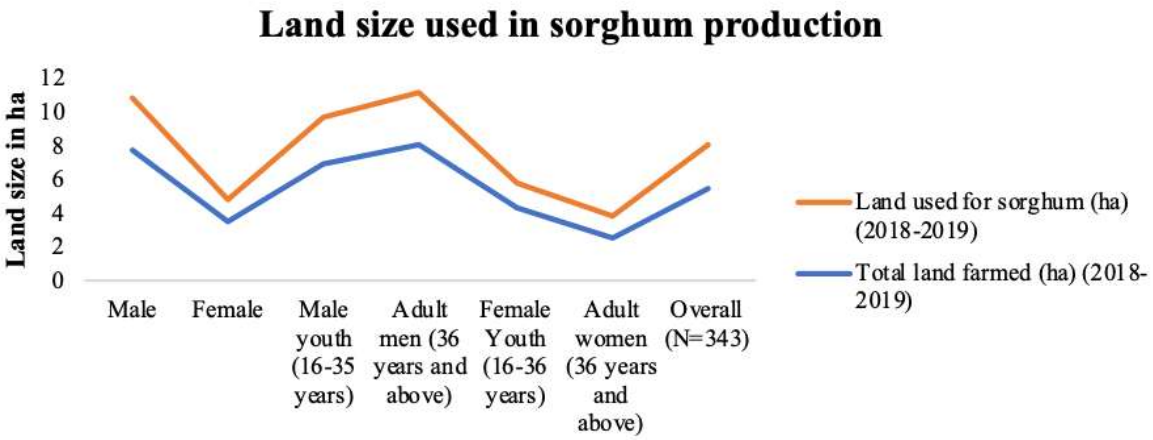

Figure 3. Total land farmed and sorghum land size (2018-2019).
Source: Author.

2 found that home consumption, trading, processing are the most important utilizations of sorghum by the respondents. The trading and processing of sorghum grains are the second most important segments of the sorghum value chain in which a high percentage of respondents are engaged. The percentage of respondents that indicated being actively in trading (5.5%) and processing (22.5%) (28% of sample size) indicates that respondents are interested and involved in market-oriented activity. The high number of women both young and older adults involved in the processing segment compared to men could be influenced by the culturally assigned roles and gendered division of domestic labour where women solely take care of all the processes of food preparation and processing. Conversely, the result showed that trading grain remains essentially a male activity due to men's ability and freedom for mobility and control on women income (Mangnus and Vellema, 2019). Male and female youths are more involved in production at 19 and 15% respectively. This large presence of young women (13%) in consumption and production nodes (15%) compared to grain trade (2%) is not surprising since in the Malian sociocultural context, young women just like older female adults are restricted to and are in charge of preparing foods and are used as laborers in most farm activities as weeding, sowing etc. Unlike young women, young men have more opportunities to engage in off-farm activities such as being *pisteurs* (middlemen), which requires travelling from village to village in search of grains for wholesale traders based in the cities (Mangnus and Vellema, 2019).

Sorghum production factors

Land access, land ownership, and land size

Land is the most essential resource for any farmer; as it remains the most important factor in crop production. Thus, the production segment is the key determinant of the functioning productivity of other segments in the sorghum value chain. During the 2018 and 2019 season, there is no significant difference between lands allocated for sorghum production to women and men farmers. However, men are growing the double of land of that of women (Figure 3). In Mali and generally in Africa, land ownership is considered as socio-cultural and economic power (Patel, 2012). Depending of the rules of ownership, growers (youth and women) can be excluded or

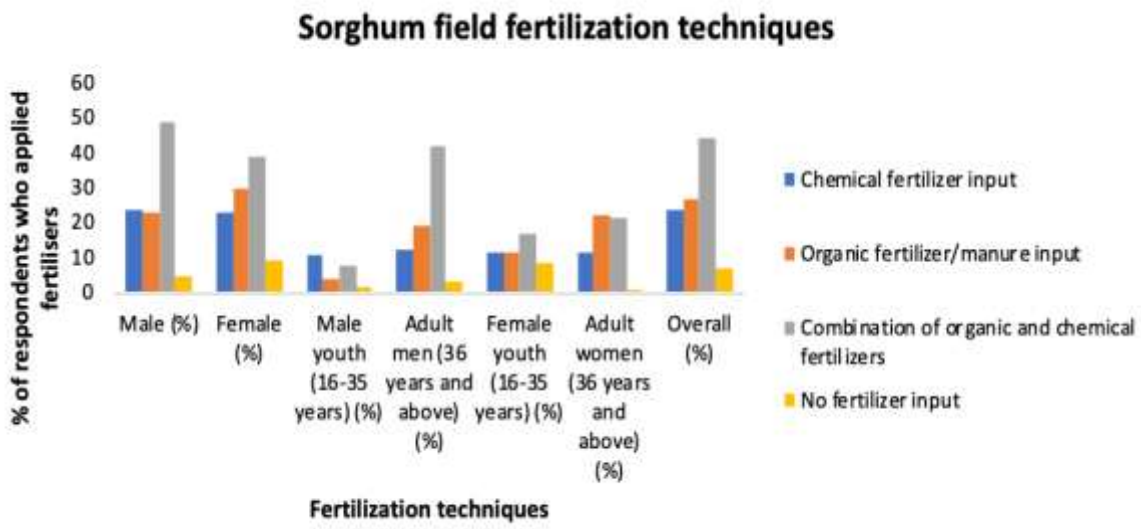

Figure 4. Sorghum field fertilization techniques.
Source: Author

marginalized in land access based on their limited bargain power (Agarwal, 1997) in the household or in the community. Our study reported the positive effect of the size of land in adoption of improved varieties which could negatively impact women adoption of new varieties. The study findings show that adult (1.28 ha) and young women (1.5 ha) cultivate about half the land cultivated by their male counterparts (2.7 ha for male youth and 3.15 ha for adult men) in sorghum.

Soil fertility and use of fertilizer

Soil fertility refers to the capacity of the soil to sustain crop production and productivity by providing essential nutrient for plants' growth. Low soil fertility is a common problem in many regions across the world, particularly in West and Central Africa where the majority of smallholder farmers struggle to cultivate crops under low soil fertility conditions (Doumbia et al., 1998; Leiser et al., 2015). Three methods of fertilization are employed by respondents in the study region which are the application of chemical fertilizer, the combination of chemical and organic fertilizers, and the organic fertilizer. The main type of fertilization applied by the farmers was the combination of organic and chemical fertilizers. Almost 46% of surveyed sorghum growers appropriated the combination of organic and chemical fertilizer while 29 and 20% solely applied on chemical and organic fertilizer respectively; whereas 5% of respondents do not make use of any fertilizer for sorghum production (Figure 4). One of the focus group discussions reveals that although the majority of farmlands have poor soil fertility, women's farmlands are however, generally poorer compared to men as reported by a woman during an FGD in Sirakele: "*It is difficult for us to get fields to cultivate, and when we get it, in most cases these fields are very poor*" (Sirakele, Female FGD, December, 2019). The data showed that fewer female farmers both young and older adults are disproportionally unable to apply or afford the use of both fertilizer types. However, much lesser percent (1.5%) of male youth compared to 8% of female youth, among the total of 9% did use any fertilizer input. In the farming landscapes of Mali, producers in general do not apply enough chemical fertilizers to produce sorghum, unlike maize that necessarily requires some good amount fertilizers. It is a well-established practice among farmers to cultivate cotton, maize, and sorghum in rotation. The fertilizers applied for the cultivation of maize and cotton support yield increase of sorghum by benefiting from the previous residual fertilizer input in the plots for maize or cotton cultivation from the previous seasons. Sorghum is known to be well adapted to low fertile which reduces the quantity of fertilizers required for its cultivation. In spite of the recommended dose of chemical fertilizer proposed by soil scientists for sorghum (10 kg/ha of urea for a yield of 1 275 kg/ha; see Traore et al, 2018, 744), most of the producers are used micro-dosing to reduce the cost of fertilization. This practice has greatly increased over the past 20 years because agricultural projects and extension services have promoted this technology.

Access to basic farm equipment

The survey revealed that about 56% of respondents have access to equipment; out of which 77% of men and 36% of women (Figure 5). The main reasons for inaccessibility

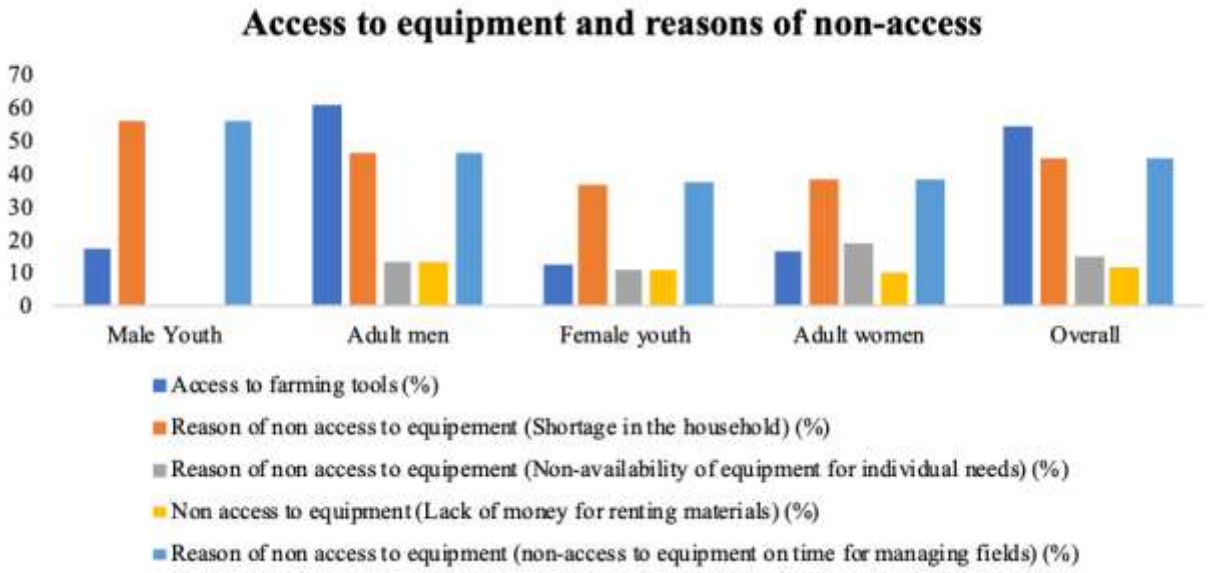

Figure 5. Access to and reasons for no access to equipment. December 2019.
Source: Author.

of the equipment are lack of money, non-availability of the equipment for individual need, and the lack of money for renting equipment. During FGDs, female respondents indicated that farms tools are prioritized for use on family fields, before it is used for the individual fields:

"…. even if having money, it is sometimes difficult to have equipment at the right period to plough field; because owners want to finish ploughing their own fields then after, they follow the queue of people that have asked for equipment for ploughing their field" (Kenie, female FGD, December, 2019).

More often when respondents mention farm equipment or tools, the most significant and basic tool referred to is the animal and small hand machine plough for used for ridging and other field operations. Figure 5 shows that 54% of respondents had no access to farming tools on time. The collective utilization of the main household agricultural tools, such as ploughs, carts and tractors, makes women dependent on men for the ploughing of their individual fields, resulting in late planting.

"The lack of equipment is one of the major constraints for us; we are sowing late because of the lack of equipment to plough our fields" (Kenie, female FGD, December, 2019).

Smallholder farmers in general are faced with inadequate and sometimes lack of access to basic farm tools for field management. Commonly in Africa and particularly in Mali, the socio-cultural practices are not in favour of women or consideration for their needs, roles and responsibilities, which negatively affect women's access to farm equipment. One such norm and cultural practice is belief or perception about the roles of women in the farming system as playing support roles to their husbands through cooking and by providing labour on farms. The consequence of cultural norms as such on women's agricultural output is the fact that more often women ask for short duration varieties to reduce the yield lost and sow late in old ridge of previous cropping seasons. The late sowing is generally explained by the lack of equipment to plough the field at right time and the effect of climate change which is explained by the shift of optimal sowing period. In addition, for reasons of unavailability of short cycle varieties, farmers use local varieties with high photoperiod sensitivity (Vaksmann et al., 1996; Rattunde et al., 2013; Weltzien et al., 2018). Many studies have underlined the importance of sowing date in crop yield performance, in particular the late sowing, can cause important yield lost (Dingkuhn et al., 2006 ; Leiser et al., 2012).

Types of crop varieties

There has been an increasing effort in developing improved varieties with the aim of helping farmers to reach food security and increase incomes. The finding revealed (Figure 6) that local varieties remain by far the most cultivated sorghum varieties by 73% of respondents, while 26% of respondents cultivated improved varieties. The adoption rate of sorghum improved varieties in this study which is less than 30% is similar to many studies (Diakité et al., 2008; Smale et al.,

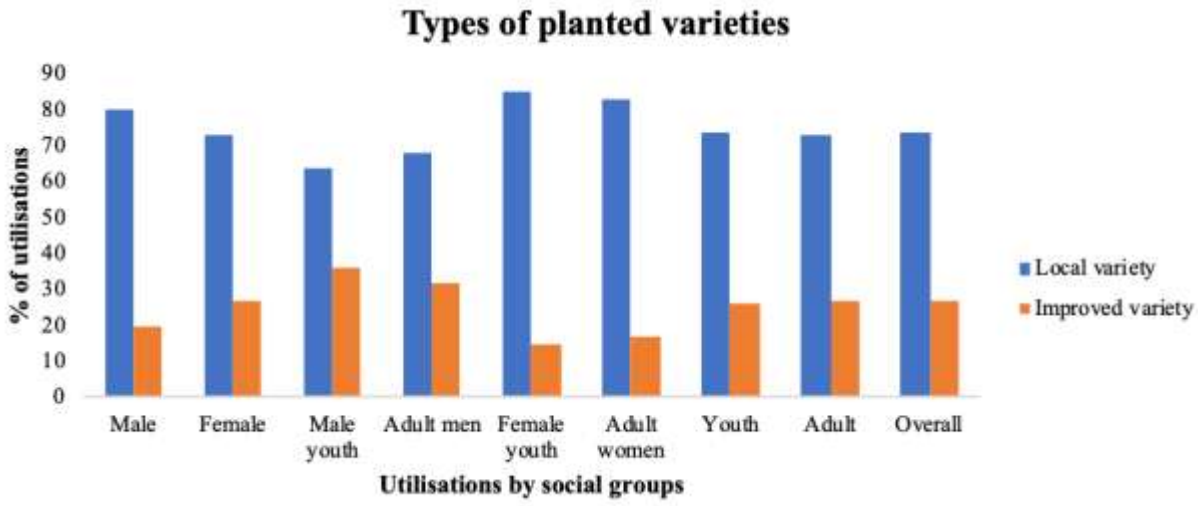

Figure 6. Types of sorghum varieties grown by respondents.
Source: Author

2016). As reported by Polar et al. (2021, 79), lower adoption of modern varieties among women producers emerges as significant trend due to their poor physically access to household farming tools. The percentage of women (27%) that were using improved varieties to produce sorghum in our study is higher compared to men. While there is no significant different between the number of adult and youth respondents using improved sorghum varieties (respectively 27 and 26%), more female farmers (youth and adult) used improved sorghum varieties than their male counterparts. A number of reasons contributing to the low adoption of improved varieties by farmers were highlighted. For example, from FGDs, these factors include: seed non-affordability and low adaptation of the improved varieties to the local environments on farmer' farm. The low level of education among farmers, and particularly female farmers, who in addition have poor networking with extension services and research institutes, and low access to land and farming tools, negatively affects the adoption of new improved varieties (Manda et al., 2020). On the other hand, some farmers reported that they preferred improved varieties instead of local varieties because of rainfall shortage and pest attacks. A woman stated this:

'*We are looking for improved varieties, because our local varieties are late maturity and the rainfall become increasingly scarce. In addition, there are some problems of diseases and insects' sensibility, etc.*" (Kalassa, female FGD, December, 2019).

This statement of the said lady must be put in its social and technological innovation contexts. The author of this quote is from a community where improved seed varieties are introduced by research institutes and farmer organizations for a while. This assumes higher awareness rate of the improved varieties. The majority of the study participants in the village are members of farmers' organization and the study area is more or less completely covered by the activities of breeding programs, which should enable farmers easily obtain information on the improved varieties (Doss and Morris 2000). On the other hand, Access to (improved) seed, as shown by Galiè et al. (2017, 2), is considered important for the empowerment of women farmers because lack of basic productive resources affects survival and hinders any path to self-determination.

Sorghum value chain actors' traits preferences by sex

Innovations such as improved varieties have great potential to contribute to agricultural production the livelihoods of value chain actors if these innovations meet users' needs and demands. Identification of desired traits in improved sorghum varieties is an important component in the breeding program modernization. The desired and identified traits and attributes help breeders prioritize and breed varieties that would be accepted by a wide range of users along the sorghum value chain. For the purpose of this, the sorghum value chain is categorized into four basic nodes: production, grain trade, processing and consumption. Individual preferences are an important dimension of the power to choose (Polar et al., 2021, 81; Kabeer, 2005). Gender inequality relates directly to power. One aspect of power is the ability to make choices (Kabeer 2005). Women and men may not have the same possibilities to make choices, and gender-related disparities often intensify the effects of poverty, creating

cycles of greater inequality. To give equal chance to choose, the sorghum value chain actors were asked to rank traits based on their importance where 1 =very important, 2= somewhat important, and 3 = not important. Based on the importance of the traits to the respondents, the most important traits were ranked first by sex and value chain nodes. This was undertaken to measure the extent to which sorghum value chain actors value the different traits of sorghum varieties (Table 3). Wilcoxon test method was used to rank the top 5 preference traits. The ranking of traits shows heterogeneity in preferences along the sorghum value chain. At the consumption *node*, there is no significant difference between the traits preferred by female and male sorghum consumers. The grain appearance (colour) is ranked among first the features preferred by men and women. For feeding purposes, even if the variety is rich in vitamins and micronutrients, meal physical attractiveness is an important driver for consumer choice. The consistency of local dishes is ranked first by male sorghum consumers and third place by female consumers. During periods of intense agricultural activity, according to FGD participants, varieties that give consistent local dishes are preferred for the simple reason that they allow them can be preserved for a long period without going bad. Digestibility and nutritional qualities were ranked third by male sorghum consumers and second by females. This result is not surprising when one considers that all these traits are related to food processing and nutrition.

As traders are the intermediaries between each of the value chain actors, they seek varieties that meet the preferences and choices of the other value chain actors. To this end, storability is ranked as the top most trait preferred by both female and male sorghum traders. Grain storability is one of the conditions for traders to sell quality products at good selling prices. Grain softness is ranked second by both male and female consumers. The grain softness is of paramount importance for the women when decorticating and pounding the grain. The softer a grain is, the faster it can be transformed with a considerable saving of time for the women. The time saved from decortication and pounding soft grains is used by women in income-generating activities or in child care. In third position, the women naturally chose the cooking quality and the men the quality of raw materials. In terms of preferred traits for processing, there was significant difference by gender in the choice of some traits. The result reveal that women preferred the high bran content for processing while men ranked the cooking quality for sorghum processing first. Grain softness is the second most preferred trait by men and women. In fourth position, men prefer decorticability while women prefer high flour content for sorghum processing. These significant differences between men and women in the processing preference traits can be explained the less involvement of the men targeted in the processing activities. The trait preferences of the production segment actors are related to the pedoclimatic and biological constraints faced by the farmers. The classification of preference traits in the production node showed gender differentiated traits. The disease and pest resistance, resistance to bird attack, and early maturity are respectively the first, second and third preferred traits for male farmers while resistance to bird attack, crop rotation performance, and disease and pest resistance are the top three trait preferences of female sorghum farmers. Even though the yield alone ranks fifth for men and fourth for women, the above-mentioned traits improve the productivity of the plants in grain and forage. It is not surprising that among women bird resistance is the most preferred trait for the simple reason that women's sorghum fields, which are usually sown late, are more prone to bird attacks than those of men. In general, a comparison of men's and women's ratings shows that traits related grain quality and food quality are highly preferred by consumers, traders, and processors, while traits related to the resistance to abiotic and biotic stresses are mostly preferred by sorghum producers. As our analytical approach is intersectional, let us analysing the preference traits by sex and age categories.

Traits ranking by value chains actors and gendered age categories

Producers trait preferences by age categories

Figure 7 shows sorghum production traits disaggregated by sex and age categories. The sorghum production traits identified by adult and young men and women are high grain yield and grain quality. But in particular, traits like easy for cooking, consistency of food, and short duration were only preferred by young women and adult women. Traits like ease to cook (that is easy to pound, decorticate) and consistence of local dishes are related to the quality of end products (grains) from the production and to food production processes which are important for women in terms of reduction of drudgery and self-esteem. When a woman cooks a food, and when this food is not edible, it is very shameful for her.

'*I could not imagine that what I am cooking is not edible. It is the supreme shame for a woman in our community. May Allah prevent this from happening to any woman. There is a variety here that I will not name, which has a grey coloured for the to (sic. the most popular dish in rural Mali), which is very high yielding, but cannot be eaten twice is the kind of variety that brings women into disrepute. No matter what we do from this variety is not appreciated. It is not the fault of the woman who prepares, but of the variety".* (Female KII, Dioila, December 2019).

That is why the quality of food is a feature that is of paramount importance to women who are concerned not

Table 3. Average scoring of importance of sorghum traits for value chain actors.

Nodes	Traits/characteristics	Average rating			Ranking of top traits	
		Male	Female	P value[t]	Male	Female
Consumption	Grain appearance (colour)	1.64	1.651	Ns	1	1
	Consistency of local dishes	1.64	1.562	Ns	1	3
	Digestibility and nutritional quality	1.611	1.586	Ns	3	2
Marketing	Grain storability	1.8	1.935	0.08117*	1	1
	Grain hardness	1.707	1.823	Ns	5	
	Grain softness	1.73	1.887	0.08373*	2	2
	Glume openness	1.73	1.852	Ns	2	5
	Easy decortication	1.703	1.836			
	Grain poundability	1.622	1.82	0.0373**		
	Cooking quality	1.644	1.885	ns		3
	Quality of raw materials (grains and fodder)	1.716	1.689	ns	3	
	Food yield	1.662	1.852	0.03826**		5ex
	Final consumer product quality	1.653	1.817	0.08993*		
	Grain quality	1.712	1.867	ns	4	4
Processing	Grain storability	1.653	1.597	ns		
	Grain hardness	1.625	1.658	ns		
	Grain softness	1.718	1.773	ns	2	2
	Large grain size	1.704	1.691	ns	4	
	Decorticability	1.704	1.732	ns	4	3
	Poundability	1.686	1.711	ns		5
	Cooking quality	1.729	1.557	0.03149**	1	
	Food yield	1.609	1.642	ns		
	End product quality	1.623	1.699	ns		
	Grain quality	1.623	1.689	ns		
	High bran content	1.652	1.841	0.03534**		1
	Grain uniformity	1.667	1.723	ns		4
	High flour content	1.706	1.653	ns	3	
Production	Panicle compactness	1.891	1.839	ns	3	5
	Yield stability	1.763	1.719	ns		
	Yield	1.873	1.855	ns	5	4
	Crop rotation performance	1.857	1.86	ns		2
	Disease and pest resistance	1.966	1.857	Ns	1	3
	Resistance to bird attack	1.941	1.875	Ns	2	1
	Early maturity	1.891	1.667	0.0042***	3	
	Late maturity	1.882	1.786	ns	4	
	Responsiveness to low fertilizer inputs	1.873	1.696	0.07793*	5	

***,** and * significance at 1, 5 and 10%; ns= not significant.
Source: Author

only with preserving their honour as housewives, but also with providing quality food for family members. To say that the dishes prepared by such a woman were insufficient and could not be eaten because of the poor quality of the grain, the flour or the breakage is the height of dishonour for a woman living in a rural polygamous family characterized by conflicts and disagreements between co-wives. The last trait that is specific to women and important for young and adult women is early maturity. In the rural mindset, the responsibility for cultivating dry cereals such as sorghum lies exclusively with the heads of households, and the maintenance of these fields is the responsibility of all household members. The rationale behind this social mode of

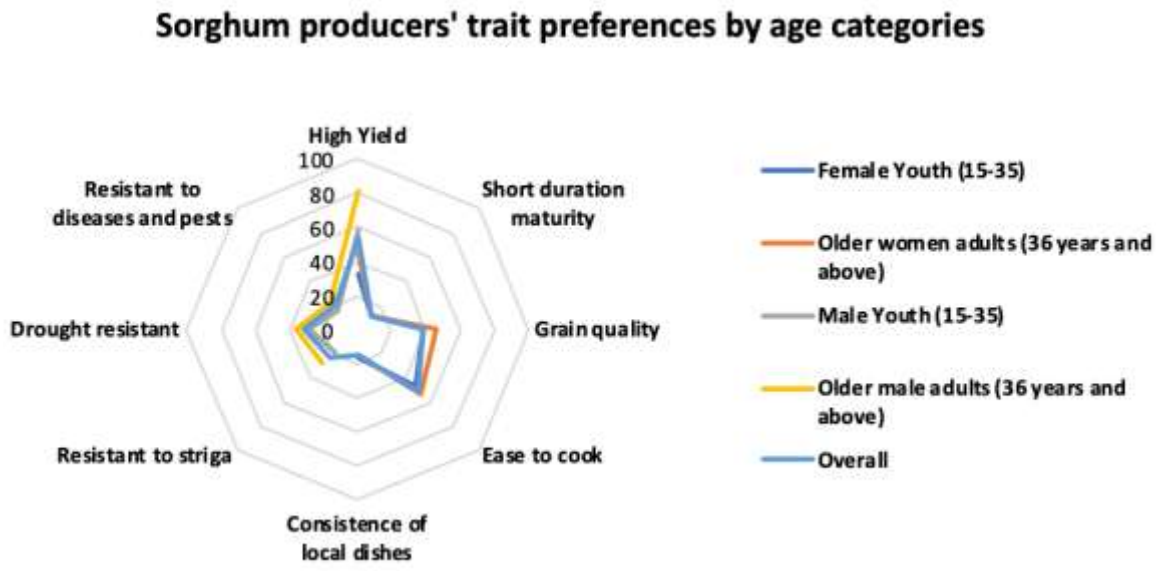

Figure 7. The most important sorghum traits preferred mostly by producers (age groups and sex).
Source: Author.

organization is that it is generally understood that the household feeding is the responsibility of the household head, while the production of the main foodstuffs (maize, millet, sorghum) is the collective responsibility of all household members and requires first the use of the household's farming tools. Based on this kind of role sharing among household members, sorghum production by women is relegated to the background because women sorghum harvests are not necessarily meant for household consumption for men, although in case of famine or during lean period, women's grain stocks are used to feed the household's children. Thus, women's fields are ploughed after the collective household fields and the individual men's fields. As a result, women sow late because of the lack of consideration of women's sorghum fields men and women limited or difficult access to family ploughing equipment or to rent farming tools during intense farming periods. However, with the early cessation of rains, late sowing is synonymous with poor harvests. This is why women favour short-maturing varieties so that with late planting they can maximize their chances of a good harvest. The study shows that traits like grain yield, resistance to diseases and pests, striga resistance, and drought resistance were specific to young and adult men (Figure 7). This result is similar with the finding of a previous study (Weltzien et al., 2019). Because of its high adaptability and its importance in food provision and income generation, sorghum is unique in its ability to grow under a wide array of environmental conditions, making it a resilient crop (Melesse et al., 2021, 4). High yield and grain quality are the traits preferred by adult and young men and young and adult women. If yield and grain quality are important traits for all surveyed producers, high yield is very important for both adults and young men while grain quality is mostly preferred for adult and young women. This shows that even if production-related traits are discussed, women are more careful about traits (such as grain quality) that are related to the consumption of the final products than men. These results show that adults and young men and women have varied experiences and expectations depending on their social roles and responsibilities in the households, which differentially influence the needs, priorities, and constraints they face individually. More often, women's and men varietal choices are guided by the plant's attributes that are linked to needs and constraints such as adaptation of crop varieties to the environments like field and climatic conditions. One of the major constraints mentioned by respondents was the low soil fertility, rain shortage, and difficult access to farming equipment. In particular, women (both adults and young) are challenged by the late access to collective farming tools and their fields are very poor compared to men's field which indicate the need for early maturity and adapted varieties to low soil fertility and drought. In addition, grain quality is a set of attributes including hardness, storage ability, food quality, and threshing ability which are important traits of sorghum varieties for production, processing, commercialization, and consumption purposes (Diallo et al., 2018).

Marketers trait preferences by age categories

The results of the study revealed that respondents are mainly growing sorghum for home consumption (60%)

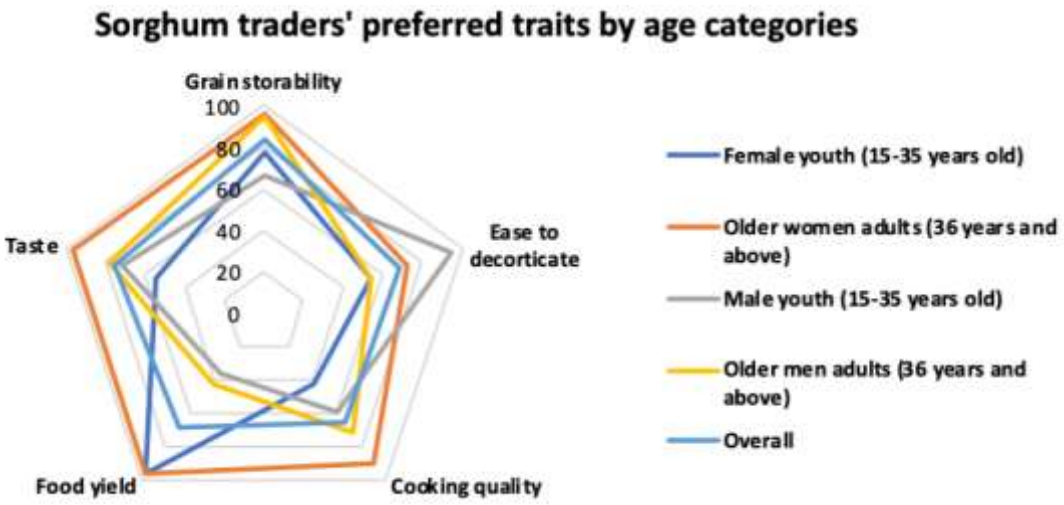

Figure 8. Sorghum traits preferred by buyers/traders disaggregated by age groups and sex.
Source: Author

and the rest are sold (26%) to traders and processed (12%; Figure 8). Before buying sorghum grains, at least 79% of traders desire the following traits: grain storability, ease of decortication, cooking quality, and food yield. These traits are important both for adult and young men and women traders, but often to varying degrees. For instance, cooking quality, food yield, and grain quality are important to adult and young women traders when they decide to buy sorghum grains while ease of decortication and taste are considered by young men traders when they market or buy sorghum grains. Grain quality, cooking quality and taste are mostly considered by adult male traders. During the FGDs and KIIs in Dioïla, it was reported that the farmers are often called upon to produce specific sorghum varieties with specific traits for the demands of partners and NGOs. These types of varieties are only produced for the market. The World Food Program (WFP) being an important client for farmer organizations when it comes to the grain sale contracts farmer organizations for the supply of sorghum grain with special characteristics for its nutrition programs (for health centres, and school canteens). For instance, in Dioïla often The WFP makes specific demands for white sorghum grains. This type of white grains is mainly *caudatum race* variety type like *Soumba, Seguifa, Grinkan, Tiandougou*, and few *guinea races* like *Seguetana* (KII, Dioila, December, 2019). High market demand is an important determinant for the adoption of particular varieties that meet the preferences of key customers. In spite of sorghum is a very important source of food and income for small farmers (FAO, 2020), it is still marketed in informal or traditional ways because of the lack of opportunities to industrially process sorghum and control of price by traders. These factors negatively impact on both sorghum production and productivity by preventing small scale farmers to substantial invest in farm inputs in order to increase the production of sorghum.

Trait preference for processing by sex and age categories

This study did not include participants involved in formal sorghum processing due to their absence in rural and peri-urban areas. Based on the poor development of processing factories in rural and peri-urban areas in Mali, the study focused more on women that are responsible for food preparation in household and engaged in the sale of manufactured food items as income generating activities in rural and peri-urban settings. The study reveals that sorghum processing activities are essentially females'; individual men are not yet fully involved in 'traditional' processing in the villages. Individual men are part of the governing board of women processing groups. This is to say that even if men have few experiences in processing, they are more in administrative, organisational and financial management and in external relations. And often, it is through these few men that the village chieftainships exercise control from a distance over the women's processing groups that have become the main focus of development agencies in recent years. As a result, the traits preferred by adult men and young men in the process are not visible in our analyses.

Figure 9 shows the traits preferred by women sorghum processors regardless of the age groups are: consistence of end products, cooking quality, ease of grinding, high flour content, and storability of end products. The analysis shows that the traits preferred by women processors are quite similar to those identified by consumers (Figure 10).

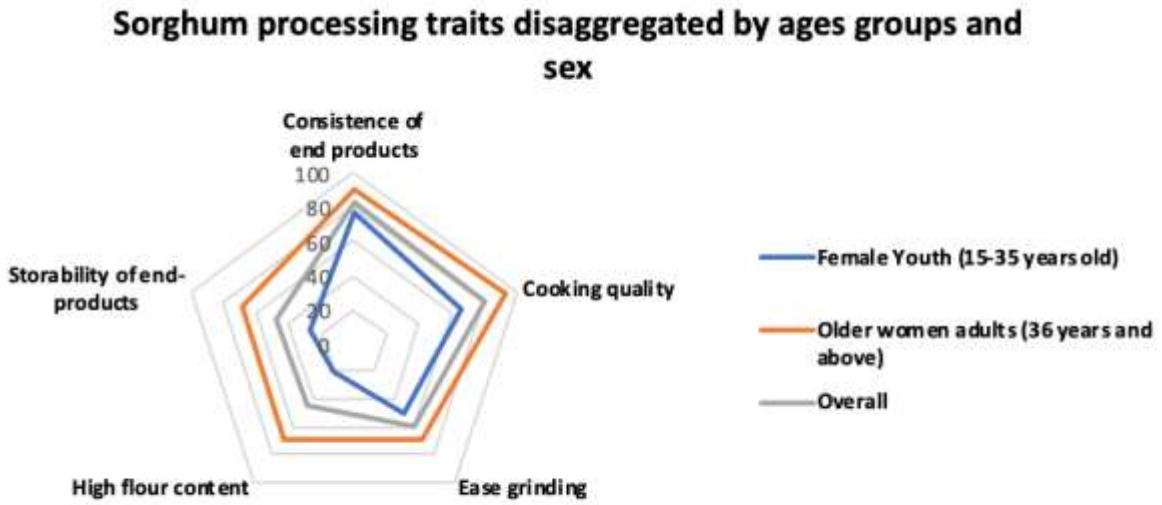

Figure 9. Sorghum traits preferred by processors (age groups and sex).
Source: Author

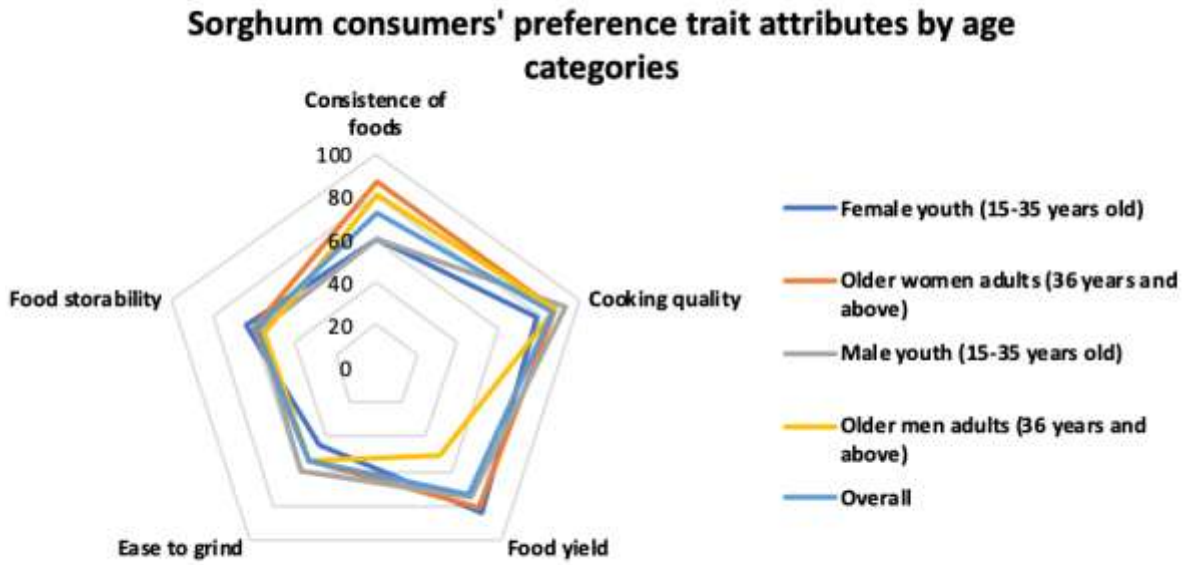

Figure 10. Sorghum traits preferred by consumers (age groups and sex).
Source: Author

During FGD discussions with Karangana mill staffs (Region of Sikasso), specific traits emerged in terms of processing demands as high flour content. Grain mills have a specific need for seeds to facilitate processing: grain storability, grain size, grain hardness, and flour whiteness. Based on these traits, workers of Karangana mill have clear understanding of sorghum varieties with specific traits of preferences:

"*For the improved varieties, we appreciate Pablo variety, because of the grain size, the white colour, and the hardness of the grains. This variety is suitable to be transformed into semolina and flour*" (Karangana, mixed FGD, December, 2019).

As the demand of flours is increasing across Mali, the development of flour mills can industrialize the processing sector, increase the income of all sorghum value chain actors, and create off-farm opportunities for youths and women who are lacking opportunity in rural and peri-

urban settings.

Traits preferences of consumers and end users

Sorghum is part of the most consumed crops in rural dwellers and by poor citizens. This crop is mainly used in the home for local meals such as gruel and thick porridge (Tô), couscous, thin porridge (cream) *Degue* and *Gningninkini*. Beyond being used as staple foods, in Tominian (Segou region) and Koutiala (Sikasso region), local beer is produced with a particular red sorghum local variety. The most important traits preferred by sorghum consumers are: food storability, food yield and food texture which is considered as food consistency (Figure 10). Moreover, there are similarities between men and women, young and adult consumers in terms of their trait preferences. Sorghum is an important source of energy, protein, vitamins and minerals for the millions of poorest people in WCA and Mali in particular (FAO 2017). *Soubatimi, Tiandougou-coura, Seguifa, Pablo, and Fadda* are some of the sorghum improved varieties which are Zinc, Fe, vitamin A content. To fight hunger and malnutrition, awareness rising campaigns toward the utilization of smart foods from high content zinc, Fe and vitamin varieties should target poor consumers of sorghum like rural pregnant women, and children under 5 years old. Sorghum plays also important role in animals feeding, in particular the dry season when the needs of fodders for animals are very crucial to feed plough oxen and small ruminants. Weltzien et al. (2018) reported that women often cultivate sorghum for special needs, such as for children's meals outside of the main meals, during the hunger times when men's stores are exhausted or for sold out to meet household expenses. In spite of its vital role in food security, sorghum does not benefit from the same support unlike maize by Malian decision makers in terms of sector structuration and input subsidy strategies.

Reflections on new avenues, engagement and participation in breeding activities

Many studies have reported on small scale farmers' participation in breeding activities which suggested is the key strategy that leads to high rate of adoption of new technologies (Weltzien et al., 2019; Diallo et al., 2018). These study findings revealed that producers participated in breeding activities through farmer organizations or agricultural extension service activities and NGOs (Weltzien et al., 2019; Diallo et al., 2018). As farmer organizations are the main actors of on-farm breeding activities, they choose or propose farm testers to conduct breeding activities. This choice is generally motivated by criteria related to the activities and farmers' personal abilities and skills. Thus, breeding activities implemented by respondent farmers are: varietal tests, demonstration tests, nursery tests (segregated population), seed production, and field visits, planning breeding activities for the following years, and training of trainers (ToT). At the beginning of breeding activities by farmers, farmer' groups organized meetings to explain and inform their members about the activities, breeding activity requirements and their benefits for community agricultural development. Volunteerism, availability and ownership of land and equipment are key criteria for involvement in participatory varietal selection activities at the community level. The bad governance in farmer organizations was impacting negatively on the participative plant breeding approach in many villages where breeding activities were started. According to one key informant in the district of Dioila, the distribution of breeding activities among organization members was not fair:

"*Some time the heads of farmer organizations influenced the distribution of some activities which can negatively impact on these activities. The fact that they receive free money and fertilizer for the implementation of breeding activities makes them exclude others. Such a management is not likely to lead to a great inclusiveness of the producers in these breeding activities*".

The advantages gained from breeding activities implemented by villagers (free distribution to inputs for the implementation of project based activities, money, participation in workshop and meetings, linkage with development institutions and research institutes) promotes the exclusion of vulnerable groups (women, youth, ordinary association members) and participates in the emergence of conflicting power relations within farmers' organizations with regard to the implementation of participatory varietal selection activities. For instance, according to a field researcher, in the district of Tominian (Segou region) where the first experiences of participatory plant breeding activities started in 2000s, women participation was a real concern. Women were somehow excluded of breeding activities because of lack of time, material and land and men strong control on women mobility. The issue of low participation of women in breeding activities was raised by a key informant in terms of lack of lands and equipment for women. Patel (2012) had similarly reported the limited participation of women in research by many factors including social norms that hindered women participation in breeding activities. Patel's study revealed that women farmers are facing difficult access equipment and land is generally managed by family men. However, Mulema et al., (2019) reported on the importance of women participation in agriculture research as key strategy to sustain agriculture development and the importance of women participation in identifying and prioritizing research problems, identifying and testing technology options. If the low participation of women in breeding activities is a general issue in agriculture in Sub-Saharan Africa, specific

constraints were identified in our research sites. In Dioïla (Koulikoro region), for instance, the main constraints in the set-up of breeding activities are the low collaboration between farmers and extension agents in the follow up of breeding activities and the lack of breeding materials or their on-time availability. One male key informant reported this:

"*We have no problem with the collaboration, but more often the material of the test (varietal test and nursery tests and demonstration and trial) arrived late and this finds that most of the producers have already sown their all fields* " (Dioïla, December, 2019).

As related to poor collaboration between farmers and extension agents, many breeding activities are project-based which means that when the project ended, the activities implemented in the framework of the project end too. To address this constraint, farmer grassroot organizations should shift from project-based breeding activities to market-oriented ones and to develop public and private partnership activities (such as networking, and to make contract with seed companies, State and NGOs). In the practice, plant breeding activities were for a long time intended for producers to the exclusion of other consumers of the products of the selection. But, the involvement of farmers, consumers, private sector, and other stakeholders in breeding cycle is essential because it enriches the selection process by considering preferences, choices, perspectives, and multiple selection criteria in environments with different contexts, value and socioeconomic backgrounds (Quisumbing and Pandolfelli, 2009). Through participation, farmers and other stakeholders gain more knowledge about new varieties, which facilitates earlier adoption through improved access to best-bet clones (Klawitter et al., 2009). Finally, if women are little included in breeding programs despite commendable efforts by research institutions, our study reveals that participatory approaches to variety selection are more focused on the production segment as if the traits that are valid for producers are also valid for other value chain actors.

CONCLUSION, RECOMMENDATION AND LIMITATION

Sorghum appeared as one of the main staple foods consumed in rural and peri-urban Mali and plays a key role in food and nutrition security of households. Despite of its importance and the continuous efforts deployed by national and international crop improvement research programs, inadequate or unavailability of quality seeds, poor climatic conditions, pest and diseases among others, have resulted to low productivity and yields, and to poor economic gains for value chain actors using current sorghum varieties which are not often meeting their needs. This study investigated sorghum value chain actors' varietal traits preferences and how intersectional and gender analysis of actors' trait preferences that can enable inclusive involvement in breeding process and influence adoption. The result of the study reveals that smallholder farmers' decision of sorghum traits are compounded by the difficulty farmers and women in particular are faced with in accessing equipment and inputs. Field management requires farm equipment and adequate input supply in all the study areas to contribute to food security and reduce labour intensity. Access to quality seed is central to crop production, farmers' access to quality seed can be facilitated by strengthen effective seed producers' involvement in the seed system to drive and improve access to high quality seeds. Concerning preference traits, farmers are mostly producers and consumers of sorghum grains which indicate that more focus should be take on farmers' preferred traits for fitting breeding objectives and prioritized those traits for breeding. When specific traits were identified and breed and all stakeholders are targeted, the needs and preferences of all value chain actors are targeted and met. The gender analysis of traits provides gender specific information on preferences and choices. The study revealed the complementarity in the choices of actors by gender (sex and age categories). Female youth and older adult females seem to have similar choice pattern as well as adult and young men due to their roles and needs within the household. Many women and men respondents have emphasized crop adaptation traits like adaptation to low input fertilizers, and grain quality traits like grain hardness, quality of the end products (that is, easy for decortication and high food yield) as essential for them and for all value chain actors. Prioritizing these traits chosen encourages appreciation of the varieties and subsequent adoption by a wide range of stakeholders or end-users. The study shows a direct association or influence of roles and needs actors within the household and value chain node on the varietal choices they made. While both male and female respondents have emphasized crop adaptation traits like adaptation to low input fertilizers, grain quality traits like grain hardness, and quality of the end products (that is, easy for decortication and high food yield) were found as essential for them and all value chain actors. However, grain quality, food quality, grain yield, and cooking quality are the most preferred sorghum traits by the female actors independent of the sex of respondents. At the consumption node, there is no significant difference between the traits preferred by female and male sorghum consumers. However, for consumption needs, the grain appearance (colour) is ranked first among the features preferred by men and women. For feeding purposes, even if the variety is rich in vitamins and micronutrients, meal attractiveness is an important driver for consumer choice. The consistency of local dishes is ranked first by male sorghum consumers and third position by female consumers.

Trait analysis through intersectional perspective (age group segmentation into youths versus adults) revealed that grain quality, food quality, grain yield and cooking quality are the most preferred sorghum traits for all segments and social categories independently of the sex of respondents. However, the study showed that gender differentiated and value chain actors' trait preferences are related to resources, rights, production norms, responsibilities and bargaining power shared and endowed by individuals. The breeding activity being about priority or step by step working, in order to prioritize identified must-have traits in breeding, it is important to focus first on adaptation traits aspects like adaptation of low soils fertility which is more complex to handle in breeding and grain quality such as and hardness which more related to grain storability, food consistency, and food storability traits. The objective of PPB being genetic plant improvement, meeting customer's needs and improving adoption of varieties, due to the intentional and instrumental character of breeding process, value chain actors' needs may be marginalized or left out of trait targeting dialogues due to the cultural context (such as low participation women, youths and private sector actors in trainings, meetings, demonstrations) and the used breeding methodologies (more focus on farmer issues to the detriment of other economic actors). Women and young people in particular are often left out of agricultural research processes, and their perspectives and needs are essential to understand and to report in order to improve adoption of new crop varieties responding to customer preferences. The needs and preferences of the value chain actors should therefore be addressed through engaging with and listening to their perspectives in terms breeding priorities for varietal trait developments. Based on these results, social and gender inclusiveness in the product development is the better way to enhance gender equality when women and men's voices along value chain are heard and effectively inform the breeding process.

For better social and gender targeting of demanded traits, it is important to reinforce collaboration between breeders, social scientists, value chain actors, and grassroots organizations to consider gender roles, responsibilities, norms, power endowments, preferences, and choices in the development of breeding products. In terms of policy recommendation, the development of adaptable sorghum varieties to abiotic and biotic stresses with high grain quality and adaptable to diverse utilizations for consumption and processing purposes is recommended for the implementation of gender-sensitive and market-oriented breeding programs. Continuous effort toward raising awareness of improved varieties and sensitization to adopt new resilient and suitable varieties to meet demands in the food production cycle is demanded by value chain actors.

Every study has limitations. One of the limitations of this study is the small sample size of grain traders and processors, although a sampling strategy had been developed beforehand in order to have acceptable numbers for each of these segments of the sorghum value chain. This is due to the fact that these two segments are not well developed in the villages and communes where the surveys were mainly carried out. An additional study with the food industry is necessary to better understand and deepen the preferences of processors.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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