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Is taking gender into account for development and diffusion of agricultural innovations justified? The case of drought tolerant maize in Northern Benin

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This study was initiated to contribute to the debate on the relationship between gender and adoption of innovations. It aims, under a participatory varietal selection, to identify the preferences of men and women farmers on maize varieties tolerant to drought in northern Benin. The methodology used is a comparison of two approaches to identify the best varieties according to gender. The first combines criteria weighting and a comparison of varieties. The second is based on the principle of democratic vote. Sixty farmers have participated in this study. The results of this work show two keys points. At the stage of criteria selection, women identified the organoleptic quality as a preferred seed characteristic. By comparing the results of the two methods of choice, it appears that both methods lead to the same results in the case of women's preferences, while in men groups, the results vary according to the methods. It contributes to the literature by showing how distinctly women can prioritize criteria that are not the top concern of the men and by the way, can contribute to increase the adoption of varieties that contains both preferences of men and women.

Key words: Benin, gender, innovation, participatory varieties selection maize.

INTRODUCTION

In addressing the issue of adoption of agricultural innovations by women, it is generally admitted that women face more constraints than men. Sethy et al. (2010), in a study of vegetable adoption by women farmers, grouped constraints of adoption of innovations as input constraints, technical constraints, socio-cultural constraints, post-harvest constraints and general constraints. Developing innovations particularly adapted to women's conditions has been proposed to improve innovation adoption among women (Morris and Doss, 1999). In this trend, some authors have come to suggest that innovations can be designated as suitable to men or women (Carr, 2008). Resolving this debate is particularly acute in the context of climate change because the role of innovation in coping with the vulnerability of farmers is becoming increasingly important.

In Benin, several initiatives have broadened the portfolio of improved maize varieties. The number of

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released varieties often categorized by maturity timing: Extra-early (75 days), early (90 days) and intermediate or late (105 days). However, adjusting the maturity rate alone may be insufficient to prevent the negative effects of drought. To remedy this situation, the National Research System in Benin has collaborated with both CIMMYT (International Maize and Wheat Improvement Center) and IITA (International Institute of Tropical Agriculture) on determining Drought Tolerant Maize varieties that may be suitable for northern Benin. A number of the drought-tolerant varieties were tested in northern Benin to assess their adaptability to the agro-ecological characteristics of the area. This article presents a case study used for determining some selection criteria of maize varieties preferred by women and men in northern Benin. Knowledge of selection criteria and preferences across gender may allow for the development of varieties adapted to gender specific conditions, which may increase the adoption by farmers.

The article proceeds with a brief literature review, a discussion of the methodological approach, presentation of the theoretical framework of the study, and lastly, the results and implications of the study are discussed. It contributes to the literature by showing how distinctly women can prioritize criteria that are not the top concern of the men and by the way, can contribute to increase the adoption of varieties that contains both preferences of men and women.“

LITERATURE REVIEW

Gender and variety selection criteria

Gender is a concept that refers to the range of roles and relationships, status, attitudes and behaviors, all determined by the social and cultural constructions of men and women, in a given society at a given time (Serme, 2013). The social construction of norms, tradition, culture or religion of a given society is influenced by gender. In this study, gender is seen as the relationship between men and women farmers who make, according to their socioeconomic characteristics, choices based on complex varietal selection criteria and maize varieties.

The complexity of the selection criteria of a variety, and the divergence observed between choices made by men and women is based on separate motivations (Defoer et al., 1997; Mulatu and Zelleke, 2002; vom Brocke et al., 2010). Segmentation of tasks in a household and farm can lead to a dislocation of the motivations of selection between man and woman. In the household, domestic activities such as meal preparation are often the responsibility of the female wives (Dembele et al., 1996). The food preparation responsibility of women often influences women's choices about the seed varieties that are used, with preference for attributes related to processing, consumption and storage.

In the case of maize, women’s production targets are often aimed toward own-consumption, while more men combine both marketing and consumption based attributes when choosing a seed (Perquin, 1993). Analyzing varietal selection in relation to gender, Defoer et al. (1997), in their analysis of maize varietal choices in southern Mali found that women rarely consider criteria related to productivity. Aspects related to the processing and organoleptic qualities, the set of characteristics that gives food its taste and flavor to consumption, were the most important seed attributes for women (Defoer et al., 1996). Mulatu and Zelleke (2002:14) found that women identified four characteristics as most important: Taste for consumption in the fresh state, earliness of maturity, size of ears and high flour yield. The high yield of flour is recognized through the hardness of the grain, because, according to responses by surveyed women, the more the grain is harder, the more flour it yields (vom Brocke et al., 2010). For men, productivity and marketability are the most important criteria (Defoer et al., 1997). Therefore, they tend to have a preference for varieties that are relatively more productive, regardless of maturity timing. While men may also participate in household food preparation, they are generally more concerned with long-term food availability than the management of short periods of food shortage (Mulatu and Zelleke, 2002).

Participation in the process of adoption

"Agricultural research is likely to produce several technologies to increase food production while conserving the land, water and genetic diversity. The real challenge is to get them using by producers “(Crosson and Resenberg, 1989:128). Adoption of innovations by farmers is often more uncertain than their invention (Crosson and Resenberg, 1989). The challenge of encouraging adoption is not new, and researchers continue to try to find effective ways to transfer innovations in rural areas. Although a guaranteed formula is still not found, it is often assumed that the participation of beneficiaries in the process of innovation increases the chances of its adoption. Douthwaite et al. (2001) showed that the need for active involvement of producers within the research team in the process of developing an innovation increases as farm technology and systems become more complex.

The observation that innovations developed according to the "top-down" approach, with little involvement by producers, were adopted by only a few producers led to increased producer participation in the innovation process. Producer participation has become more common in the field of plant breeding because it is believed that producers have rich endogenous knowledge as well as cultural habits that allow them to better select appropriate varieties that could be used on the farm (Sperling et al., 1993; Witcombe et al., 1996). Some authors try to establish whether a positive correlation between producer participation in plant breeding and adoption rates exists.

Table 1. List of varieties tested and evaluated by town.

Village	Average annual rainfall (mm)	Cycle	Scientific name of varieties
Angaradebou (Kandi)	850	Early variety (90 days)	DTSTR-YsynF2; IWDC3syn/DTsyn-1-W; IWDC3synF2; IWDC3synF2 and FAABA/QPM (control)
Kokey (Banikoara)	850	Early variety (90 days)	EVDT-Y2008STR; TZEWDT-STRQPMCO ; TZEcomp3DTC1F2; EVDT-Y2000STR and EVDT97STR (control)
Tombouctou (Malanville)	750	Extra-Early variety (75 days)	2008SynEEWDTSTR; 2008SynEEYDTSTR; TZEE-ypopSTR QPMCO; TZEE-W pop STR QPMCO and 2000SynEEW (control)

Defoer et al. (1997), in their analysis of adoption rates in Mali, found that producer participation is an important factor to improving the adoption rate. Mulatu and Zelleke (2002) argued that improving producer participation in the breeding process is a necessary condition for improving the adoption rate because it increases the level of acceptability of new technology among producers. In the same vein, Virk et al. (2005) and Ceccarelli and Grando (2007) identified selection of seed traits by producers as important for accelerating the diffusion and adoption of new varieties. Because women play a key role in the household and in production, they should also be included in the innovation production process. vom Broecke et al. (2010) pointed out that accounting for the contributions of women and men in meeting the household needs can be essential information in the process of plant breeding for identifying varieties that have a high likelihood of adoption.

METHODOLOGY

Study area

The present study was conducted in northern Benin. Geographically, the study area is between the parallel 09° 45 'and 12° 25' North latitude and meridians 0° 45 'and 3° 20' East longitude. The effects of climate variability are more exacerbated in north than in south due to the single rainy season that characterizes it. This area is characterized by an annual rainfall deficit with a variation range from 900 to 1100 mm rainfall. The Department of Alibori was chosen to conduct this study. According to Agbossou et al. (2010), the departments of Atacora and Alibori are among the departments with high sensitivity and potentially vulnerable to climate change in Benin. Districts of Kandi Banikoara and Malanville were chosen because of their production level of maize in the department and also the fact that maize is classified as the most sensitive food crop to the effects of climate change (Agbossou et al., 2010). One site was chosen in each district for experimentation, and these include: Angaradebou in Kandi district, Kokey in Banikoara district and Tomboutou in Malanville district.

Research methods

In each village, five varieties are tested (Table 1). Four of the tested varieties are drought tolerant, and breeders newly proposed all of the drought tolerant varieties. The fifth, a non-drought tolerant variety that is universally recognized by farmers as the most commonly planted in the village, serves as a control.

Producers who hosted the trials were selected in collaboration with the technicians of the National Agricultural Research Institute of Benin (INRAB) on a voluntary basis. At each site, 10 women and 10 men were selected to participate in the trial. Each variety is a treatment, and each treatment has a basic plot of 400 m^2 separated by aisles of 2 m wide. The evaluation tests by farmers (men and women) are fundamental in this research. Two types of assessments were made according to gender. Generally, in the area where the observations were made, men plant maize on four times more area than women. Harvest of women is primarily built into the stock devoted to household consumption, while men expect the largest share of their harvest to be sold on the market.

Initial evaluation: Indirect prioritization based on predefined criteria and weighting

The methodological approach has two phases: the weighting of criteria, and evaluation of varieties with regard to the weighted criteria. In each group of ten men and ten women, farmers were asked to list the selection criteria for maize varieties. The criteria mentioned are represented by symbols or figures chosen by farmers to fully enable participation. N points are distributed on the mentioned criteria. This process of weighting criteria follows the principles of equality and secret choice. The principle of equality is implemented by the choice of an equal number of women and men, and each has one vote. The principle of secret vote for the weighting is justified by the need to avoid the influence of other farmers in the group of participants on the allocation of points. Thus, all producers have assigned their points criteria away from the others in a booth in the presence of an observer who ensures compliance with the conditions of the vote. The results of vote were presented to all producers participating in this evaluation. The weight of each criterion is determined by the formula:

$$wj=Tj*100 / N * k$$

with Tj the total number of points allocated to criterion j, k the total number of women or men who participated in the evaluation and N the total points that each man or woman to all criteria. This number is fixed and in this study (N = 10).

The Kendall test was performed to check whether the choices made by women and men within each group allow one to estimate a trend, or whether the choice of each member of a group is an isolated choice. The formula of Kendall's W coefficient is:

$$W = 12S/ [k^2 (q^3-q)] \quad (1)$$

where K is the number of producer (men or women) and q the

Table 2. Criteria used for the evaluation of maize varieties.

Criteria		Men	Women
Common: Angaradébou, Kokey and Tomboutou		Yield of the variety, resistance to striga, resistance to drought, cycle of production	
		Grain color	Organoleptic quality
Specific	Angaradebou	Starch content and grain size	Length of post-harvest conservation and plant size
	Kokey	Plant size and organoleptic quality	Grain color and appearance
	Tomboutou	Starch content and grain size	Grain color

number of varieties (q = 5). S is the sum of squared deviation and is obtained by $S = \sum (R_i - m)^2$ (2) where R_i is the rank of a producer i and m is the mean rank within each group of producer. By combining (1) and (2), $W = 12 \sum (R_i - m)^2 / [k^2 (q^3-q)]$.

If *W* is 1, then all the producers, men or women have been unanimous, and each producer has assigned the same order to the list of objects or concerns. If *W* is 0, then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of *W* indicate a greater or lesser degree of unanimity among the producers.

After determining the weight of each criterion, men and women evaluate varieties. The evaluation process results in ranking varieties. The score used for ranking is obtained by multiplying the number N of points for each criterion and for each variety. The score SVi of a variety i is obtained by the combination between the weight of the criterion and the point assigned according to the formula: $SVi = \Sigma nj * wj$ with wj the weight assigned to a variety i for criterion j (Σwj = 100%) and nj, the number of points assigned to criterion j ($\Sigma nj = N = 10$).

Second evaluation: Direct prioritization

Direct prioritization is based on a comprehensive assessment that does not clearly specify the criteria, but rather allows the producer to rank his or her preferred varieties directly, from most to least preferred. All participants are invited to rank the varieties in order of preference. The list obtained through direct prioritization is compared to the first assessment to verify consistency of choice by groups of men and women.

RESULTS

Criteria for evaluation of a variety

Table 2 shows the shared and unique criteria chosen during the trials at different sites. Four variety criteria are shared among all men and women in the three sites, which are: Yield, resistance to drought, resistance to striga and length of the production cycle. Women in all three sites preferred the organoleptic quality, or the taste and flavor of the maize, while only the men at Kokey mentioned this as a preferred criterion. Women in at least two of the sites also preferred the criteria mentioned by men as their most important criteria.

Women and men chose a similar number of selection criteria. These similarities are related to the number and the nature of the criteria. Men and women chose seven evaluation criteria in each of the sites, with the exception of women in Malanville, who chose 6.

Importance of each criterion in the evaluation of a variety

The weighting of the criteria of varietal selection at the three experimentation sites varies among men and women (Table 3). In each site, men and women provided different weights for a given criterion. Comparing the same criterion across sites, men and women also provide varying weights. Some criteria were not provided any weight by the men, while all criteria were at least given some weight by women. Women, therefore, better allocated points across the various criteria that related to both production and consumption of maize.

The results of Kendall's test show that in each group, a shared behavior among members of the group emerges. All Kendall test are significant at 5%. The rankings obtained by the classifications of the Kendall test are consistent with the weights obtained. We can, therefore, conclude that the importance given to each criterion within each group follows a common decision making process that is likely determined by consumption, production or marketing related factors, such as yield, maturity length, etc.

Variety selection based on specific criteria

Table 4 presents the results of the ranking of varieties by women and men in the three sites. In Angaradebou, the DTSTR-WsynF2 variety had the highest score among men and women. In Kokey, the varieties, TZEWDT-STRQPMCO and TZEcomp3DTC1F2, ranked the highest among men. Women, on the other hand, ranked the DTSTR-WsynF2 variety highest. In Tomboutou, the highest-ranking varieties were different for men and women, with 2008SynEEYDTSTR having the highest score among men and TZEE-Wpop STR QPMCO with the highest score among women.

Selection on the basis of direct choice

The results from the direct ranking selection trial, with varieties obtaining the highest scores being ranked first and those with the lowest scores ranked last, are shown in Table 5. The table also shows that the comparison of two methods of prioritization leads to the same results among women, while the results differ across methods

Table 3. Weighting of each criterion.

Criterion	Angaradebou (%)	Kokey (%)	Tomboutou (%)
		Men	
Cycle of production	21	18	20
Grain color	5	0	0
Grain size	7	Not cited	13
Organoleptic quality	Not cited	0	Not cited
Plant size	Not cited	25	Not cited
Resistance to drought	7	17	0
Resistance to striga	14	40	37
Starch content	12	Not cited	0
Yield of the variety	33	0	30
		Women	
Yield of the variety	33	29	20
Resistance to drought	6	6	14
Resistance to striga	13	13	12
Cycle of production	8	15	15
Organoleptic quality	5	1	21
Length of post-harvest conservation	13	Not cited	Not cited
Grain color	Not cited	13	18
Appearance	Not cited	23	-
Plant size	22	Not cited	Not cited

for men. This difference is partial in Angaradebou, pronounced in Tomboutou and totally in Kokey. These results reflect the relative coherence and consistency in the choice of new technologies among women when compared to men.

DISCUSSION

Results show that there are some common varietal selection criteria that are preferred by men and women, regardless of the maturity cycle of the variety (early or extra-early) and the site of the testing. These shared criteria are yield, cycle, and resistance to striga and drought. These criteria remind one of the goal of varietal selection which is to provide the household with food in sufficient quantity and quality. Beyond these common criteria for men and women, there is a criterion mentioned by women in each of the three trial sites, which is the organoleptic quality, or taste and edibility, of maize varieties. These results confirm those of vom Brocke et al. (2010), who, in a study on participation in the development of a variety of sorghum, found that the grain quality for culinary aspects, as well as productivity in the form of flour, are important criteria for women. Therefore, we endorse the vom Brocke et al. (2010) recommendation that women be included as early as possible in the selection process and evaluation varietal selection in northern Benin.

Women and men in the site of Angaradebou both selected the variety DTSTR-WaynF2 as that which best suits their needs. Sometimes they are more experienced than men as it is the case on the site of Kokey. In Kokey, men preferred two varieties simultaneously, while women ranked one variety highest. This variety is one of the two best varieties selected by men, which is consistent with the finding of shared preferences across genders from Angaradebou. In Tomboutou, the situation seems to be more nuanced. The two best varieties by men are 2008SynEEYDTSTR and 2008SynEEWDTSTR, while in women group, it is the TZEE-WpopSTRQPMCO variety, which was ranked fourth out of the possible five among men.

Implementing the selection of varieties on the basis of direct choice allows for checking of consistency of choices of preferred criteria among trial participants. It appears that the direct choices, or rankings, of varieties made by women confirm those made on the basis of specific criteria, while men ranked varieties differently in direct choice and specific criteria. In Angaradebou, rankings among men and women give the same results across the choice methods. In Kokey, selection results from direct choice allow for a definitive ranking of the two varieties with the same score in the specific criteria trial. In Tombouctou, the methods provide differing results. The consistency of the results of women at all three sites could be the result of a logical process of choice based on their knowledge of maize varieties. By keeping practice farming and hold keys function as sowing and harvesting, women learn to differentiate the varieties.

Table 4. Ranking of maize varieties.

Site	Men		Women	
	Criteria	**Rank**	**Criteria**	**Rank**
Angaradebou	Cycle of production	5.09	Cycle of production	3.5
	Grain color	2.82	Length of post harvested conservation	4
	Grain size	3.14	Organoleptic quality	3.2
	Resistance to drought	3.36	Plant size	4.5
	Resistance to striga	3.95	Resistance to drought	3.2
	Yield of the variety	5.86	Resistance to striga	3.8
	Starch content	3.77	Yield of the variety	5.8
	W of Kendall = 0.317; ddl= 6; p= 0.02		W of Kendall = 0.236; ddl=6 ; p=0.028	
Kokey	Cycle of production	4.6	Appearance	5.5
	Grain color	2.5	Cycle of production	4.15
	Organoleptic quality	2.5	Grain color	4.05
	Plant size	5.1	Organoleptic quality	1.8
	Resistance to drought	4.4	Resistance to drought	2.75
	Resistance to striga	6.4	Resistance to striga	3.9
	Yield of the variety	2.5	Yield of the variety	5.85
	W of Kendall = 0.639; ddl = 6; p = 0.00		W of Kendall =0.49 ; ddl= 6; p= 0.00	
Tombouctou	Cycle of production	4.75	Cycle of production	3.35
	Ear size	4.1	Grain color	3.9
	Grain color	2.75	Organoleptic quality	4.25
	Resistance to drought	2.75	Resistance to drought	2.85
	Resistance to striga	5.65	Resistance to striga	2.7
	Starch content	2.75	Yield of the variety	3.95
	Yield of the variety	5.25		
	W of Kendall = 0.485; ddl = 6; p = 0.00		W of Kendall = 0.14; ddl = 5; p = 0.026	

Howard (2003) stated that women are the biggest holders of local knowledge on plants and a simple explanation for this observation is that throughout history, the daily work of women required the most of these knowledge. In this case study, results suggest that women are more experienced in varietal selection than men. The results supplement the findings of several studies that have shown in the past that women have some advances on men in varietal selection and recognition of cultivars. Flickinger (1997) showed that women's knowledge about the usefulness of wild plants is larger than those of men, and they perceive their use differently. Women often have a portfolio of broader criteria than men varietal selection, because they have been found to use plant material more diversely. For example, rice is not only used for consumption. Rice straw is used to thatch roofs, make mats and animal feed, and the husk is used for the manufacture of fuel (Jiggins, 1986). Postharvest responsibility, commonly undertaken by women in developing countries, for treatment and food supply of the family involved that they try to ensure that the varieties used are consistent with the culinary traditions, are tasty and nutritious and meet the requirements of processing and storage. In the Andes, the birthplace of the diversity of potatoes in the world, research shows that agronomic conditions explain only a small percentage of the variation in crop diversity (Zimmerer, 1993). The maintenance of varieties of potato and maize is explained primarily by due to different culinary demands (lyophilization, soup, porridge etc.) (Zimmerer, 1993).

Conclusion

This study showed two significant results. The first finding is that women have shown a preference for drought tolerant maize for planting in northern Benin. In all trial sites, women have shown consistency and accuracy in their rankings of both preferred individual varietal attributes and preferred varieties. The second finding is that there appears to be a need to take into account gender-specific varietal selection criteria, justifying the integration of both men and women in the innovation process. Through each stage of the varietal selection, women brought particular valuable options, making them important actors in participatory varietal selection. The results of this work show that it is possible to define

Table 5. Farmers varietal preference.

Variety	Score	
	Men	Women
Angaradebou		
DTSTR-WsynF2	2.52	2.34
DTSTR-YsynF2	2.02	2.11
FAABA/QPM (control)	2.19	1.87
IWDC3synF2	1.65	2.18
IWDC3syn/DTsyn-1-W	1.93	1.48
Kokey		
EVDT97STR (control)	0.98	2.19
EVDT-Y2000STR	0.98	1.87
EVDT-Y2008STR	1.2	1.88
TZEcomp3DTC1F2	1.23	1.87
TZEWDT-STRQPMCO	1.23	2.66
Tombouctou		
2000Syn EEW (control)	2.85	1.71
2008SynEEYDTSTR	3.29	1.76
2008SynEEWDTSTR	3.09	1.55
TZEE-W pop STR QPMCO	2.72	1.8
TZEE-ypopSTR QPMCO	2.11	1.63

technological packages that meet both the divergent interest of men and women. Men tend to seek market-oriented varieties, like with attributes such as yield, color, grain size etc., and women choose varieties with consumption-oriented qualities, such as organoleptic quality, starch content, length of post-harvested conservation etc. Involving women in the process of developing a technological innovation can help to ensure that women's criteria are taken into account in the development of innovations. Moreover, improved varieties which can include both market- oriented and consumption-oriented may be more desirable to ensure food consumption and nutrition while bring significant revenue for household. Preference toward improved varieties among women can lead to achieving desired food security outcomes by improving the quality and quantity of maize consumed from own-production in a country where maize is a staple food.

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Conflict of Interest

The authors have not declared any conflict of interest.

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