Gender Differentiation of Farmer Preferences for Varietal Traits in Crop Improvement: Evidence and Issues

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Gender equality is central to the three CGIAR strategic objectives of reducing poverty, improving food and nutrition security, and working towards sustainable, resilient agro-ecosystems. CGIAR's approach to addressing gender inequality in its research has two main goals. The first is to build capacity to address the gender dimensions of agricultural research and development across the CGIAR System, and the second is to integrate gender into individual CGIAR Research Programs (CRPs).

The CGIAR Gender and Agriculture Research Network was a cross-CGIAR Research Program community of practice for researchers, principally social scientists, whose work focused on or included gender. As of 2017, the Network has evolved into the CGIAR Collaborative Platform for Gender Research hosted by the CGIAR Research Program on Policies, Institutions and Markets (PIM) and coordinated by the Royal Tropical Institute (KIT) in Amsterdam.

Working papers are intended to (1) provide members of the community of practice with a quick entry into a topic of general interest and importance through a literature review commissioned by the Network and (2) facilitate members' knowledge sharing about their work in progress through the circulation of such papers before full publication.

Working Papers, published only in electronic format, contain preliminary material and research results. Papers are reviewed prior to circulation. The goal is to stimulate discussion and critical comment. It is expected that these working papers could eventually be published in some other format with revised content.

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Abstract

Changes in agro-ecological as well as socio-economic conditions lead to transformations of food and farming systems worldwide. Using plant varieties with new or different sets of traits can be one option for farmers to adapt to these changes; however, coping strategies and related varietal traits may vary for different groups of farmers, depending for example on their access to resources and assets, and their production goals. Gender is one major social category for which differences in this regard can be expected.

Developing gender perspectives in plant breeding can thus be seen as part of a general approach to improving the scientific understanding of agricultural systems, and to understand the needs for, as well as potential benefits of, new technologies for specific groups of users. Genomic breeding, for example, offers new opportunities for addressing diverse farmer preferences for varietal traits more specifically in breeding programs, if plant breeders can anticipate which traits and trait combinations bring benefits in the specific crops, cropping systems and for the target farmer groups.

Hence, the overall aim of the present work was to systematically review the “state of the art” of gender differentiation with regard to varietal trait preferences in order to identify options for breeding programs to better address gender-specific needs, and how they may need to change in order to become more gender-sensitive. Specific objectives were to study the extent to which such differences have been documented in scientific literature, the methods used and what patterns of gender-differentiated trait preferences can be identified.

For this purpose, we conducted a literature search in English-language sources, focusing on studies and projects where data collection had been done between 1985 and 2015. Those studies, if they presented information on gender-differentiated trait preferences, were included in the review and evaluated in detail, e.g. for the overall set up of the study, the methods used and the data provided. The results of the evaluation were summarized and analyzed.

The review identified 39 studies, the majority focusing on study areas in Sub-Saharan Africa and major cereal crops. Less studies covered legume crops, root and tuber crops or other vegetatively propagated crops, or crops of regional importance. In most cases, the main focus

of the work was not on varietal trait preferences, but on related issues, such as participatory breeding, biodiversity conservation, seed systems, or on more general topics, such as agricultural systems research or ethnobotany. Most studies used more than one method to identify gender-differentiated trait preferences, including, for example, interviews and surveys, Focus Group Discussions as well as on-farm and on-station observation or selection.

Overall, men tended to focus more on production and marketing-related traits, and women more on production and use-related traits. However, where women and men faced similar constraints, they tended to mention similar trait preferences, whereas differences occurred when women and men farmed under different conditions, if they had different roles and responsibilities in the production process or grew the crop for different purposes, or if crops were grown only or predominantly by either women and men.

A general observation is that women in many cases focus much more on traits that are related to post-harvest processing and food preparation, since these are activities typically performed by women in many cultures. Related traits were, for example, storability, grain characteristics, losses during the decortification process or swelling capacity of flour. Furthermore, women more frequently mentioned traits that are related to family food security, e.g. earliness, multiple harvests, production even in ‘bad’ years or under poor soil fertility conditions.

In many cases, women and men do not need separate varieties, but varieties that include the preferred traits for both genders. In that way, breeding programs could effectively address major obstacles for adoption of ‘improved’ varieties for local processing and use, and increase impacts and benefits for users.

Furthermore, the results of the review highlight the importance of deepening the understanding of gender-specific differences regarding conditions, roles and responsibilities for the cultivation, use and marketing of crops. Such insights could guide plant breeders towards addressing gender-specific preferences for varietal traits in a more systematic manner. This would require appropriate methods and tools to be routinely used in breeding programs to study specific problems, needs and constraints of different groups of users.

The general dilemma that breeding programs tend to reduce the number of traits targeted to improve selection gains while farmers' preferences and needs are diverse, can be accommodated to some extent by a number of methodological approaches that have been developed in the last two decades, even if their original focus was not necessarily on gender-specific traits. These include the choice of parental materials, combined with new breeding techniques such as genomic and marker-assisted selection and options for decentralization and collaboration.

New breeding techniques can best contribute to addressing gender-differentiated trait preferences if they form part of such integrated approaches, and rely on careful diagnosis of the diverse strategies, needs and goals of women and men working with the crops a breeding program focuses on. This would actually require a sound methodology and gender-inclusive participation structure when planning for crop development programs at various levels – internationally, regionally, nationally, and locally.

1 Introduction

Farmer preferences for varietal traits vary according to the agro-ecological and socio-economic conditions under which farmers work, and their production goals. Both sets of circumstances are variable and evolving over space and time, whereas coping strategies for adapting to these changes and related production goals may vary among different groups of farmers, e.g. based on their resource and capital endowments, or available infrastructure.

In general, plant breeders can best contribute to these transformations by deepening their understanding of these changes and related strategies, and thereby anticipating interesting traits and trait combinations for the specific crops, cropping systems and groups of farmers they are targeting. In other words, they need to develop a system understanding and define their breeding work based on the identification of relevant options for system improvements (Mazón *et al.*, 2016).

Gender issues come into play if the conditions under which women and men engage in farming are different, if they undertake complementary activities or have different responsibilities or production goals, if gender dynamics and norms affect livelihood strategies or adoption of technologies, or if women and men develop different strategies, e.g. based on systematic differences regarding resource and capital endowments.

To be effective, e.g. in terms of improving yield performance, income or nutritional benefits, breeding programs need to target the needs and conditions of potential target groups of users (Efisue *et al.*, 2008). For enhancing crops that are predominantly grown by either women or men, or that are grown by women for other purposes than by men, gender-specific knowledge about production systems and post-harvest use may be required. This is why adopting a gender perspective might be considered as part of a general approach to improving efficiency and client-orientation in breeding programs.

Plant breeding is a scientific area, where progress continues to be made at a fast pace, resulting in the dynamic development of new technological applications. Genomic breeding, for example,

offers new opportunities to address diverse farmer preferences for particular varietal traits more specifically in breeding programs (Louwaars *et al.*, 2006).

This is why the CGIAR Gender and Agriculture Research Network's Gender and Breeding working group convened a workshop on "Gender, Breeding and Genomics", which was held in Nairobi, Kenya, 18-21 October, 2016. The goal was to increase the relevance and benefits of plant and animal breeding for resource-poor rural women producers in low-income countries, especially in Africa, and to close the existing knowledge gaps that currently hold back breeding programs from becoming more gender-responsive[1]. The work presented in this paper is based on the authors' joint contribution to that workshop.

2 Objectives and scope of work

Plant breeding can bring benefits to farmers, be they women or men, if it helps achieve genetic gains for traits that are relevant to them. What traits are relevant to which farmers varies depending on the crop, context and situation. However, the general aim of our study is to look at women's and men's varietal trait preferences *across* various crops, contexts and situations in order to better understand under what circumstances or conditions gender-differentiated trait preferences can be more likely expected.

Furthermore, improved knowledge on gender-differentiated trait preferences could help identify options for breeding programs to better respond to gender-specific needs, and possible ways how they might need to change in order to better integrate gender considerations.

The attention given in this study to trait preferences reflects that it is of particular importance to plant breeders, especially with regard to the options for making use of new breeding techniques. However, the authors are well aware that the topic of 'gender and plant breeding' is in fact much

[1] https://gender.cgiar.org/gender-breeding-and-genomics-workshop/

broader and cannot be fully covered by a focus on traits alone. Thus, this study is seen as a specific contribution to the broader topic.

Hence the goal of the present work is to review the "state of the art" of gender differentiation with regard to varietal trait preferences and to synthesize findings and their implications for breeding programs.

More specifically, the paper aims to review:

- the extent to which gender-differentiated trait preferences have been studied and documented in the scientific literature;
- the goals or motivations for addressing gender and/or other socio-economic categories in relation to trait preferences;
- the methods used to identify gender-differentiated trait preferences; and
- if patterns of gender-differentiated trait preferences could be identified from the cases documented in the literature.

Furthermore, attention was paid to geographical, commodity and agro-ecosystem coverage achieved by the studies reviewed.

3 Materials and Methods

The overall approach of this study was based on interdisciplinary cooperation among plant breeders and social scientists with experience in the topic. The literature review was conducted in six consecutive steps:

Step 1: Literature search in English-language sources

Scientific databases were used (EVAFA, SOWIPORT, JSTORE, CAB, Web of Science) and the search focused on studies and projects that were conducted in the period 1985-2015. The search criteria, used in in various combinations, were: gender, farmer, women, traits, plant breeding, preference, seed, selection, variety. In order to complement the results of this search, researchers who were assumed to have conducted some work in the area were contacted directly and asked for relevant reports or publications, to make the review more complete and bridge possible gaps.

Step 2: Establish criteria for the identification and selection of case studies

The main selection criterion for including cases in the detailed review was that the paper provided some evidence, quantitative or qualitative, for gender-differentiated trait preferences. We included some studies that focused on women only, if they provided evidence for trait preferences in varieties of the crop in question. We did however not include studies that compared preferences for different crops, or even those that provided evidence for gender-differentiated preferences for different varieties, if these differences were not explained by the trait differences exhibited by these different varieties.

Step 3: Selection of case studies

Those studies that corresponded to the above criteria (Step 2) were collated in a database for further evaluation.

Step 4: Establish an evaluation matrix for the analysis of case studies

An evaluation matrix was established that included basic information, e.g. on the years when data were collected, on regions, countries, cropping systems and crops targeted, on the institutional setting and whether the study was related to a breeding or seed dissemination program. Furthermore, the methods used were analyzed, such as the unit of analysis (e.g., individuals, households, groups, etc.), the number of units analyzed, the socio-economic data collected (other than gender), the type of methods that were used, and for which other issues (except trait preferences) the study presented gender-differentiated information (see Annex).

Step 5: Analyze case studies

The evaluation matrix (Step 4) was then applied to each of the case studies selected in Step 3.

Step 6: Review, discussion and summary of results

A table was built to classify, group and describe the studies according to the issues addressed, e.g. foci of the studies, methods used, institutional arrangements and results obtained. Preliminary results were discussed among the authors and with participants of the "Gender, Breeding and Genomics" workshop in Nairobi, Kenya, based on the authors' contribution to the workshop. A synthesis of the findings is presented in this working paper.

4 Results and discussion

4.1 Overview of cases identified for the review

A total of 39 studies were identified that reported crop trait preferences in a gender-differentiated manner or described trait preferences for crops primarily cultivated and characterized by women. The majority of these studies examined staple cereals (maize (12), rice (6), sorghum (5), pearl millet (4) and wheat (1)). A number of studies also examined major legume crops (beans (4), cowpea (1)). Root and tuber crops and other vegetatively propagated crops (sweet potato, cassava and banana) and crops of regional importance (Quinoa and Kersting's groundnut) were represented by one study each. These crops represent the range of breeding systems, from the predominantly cross-pollinated crops (maize and pearl millet), to primarily self-pollinated (beans, cowpeas, wheat, rice and sorghum) and clonally propagated crops (cassava, sweet potato and banana).

The majority of the studies came from Sub-Saharan Africa (72%), with the remainder from Latin America (15%) and Asia (13%). The oldest study found was published in 1993, followed by another six publications up to 2000, and thereafter a quite constant rate of approximately two studies per year up to date.

The study authors, quite balanced by gender, represented a diverse array of institutional affiliations (Table 1). A high level of multi-institutional collaboration was evident, with 85% of the articles having two or more collaborating institutions and 44% three or more. International and national research organizations, together with universities outside of the study country contributed

the most frequently. Local universities, farmer organizations, national extension and development institutes, although less frequently, were also important contributors, whereas development NGOs rarely contributed. Lead authorship, however, represented more narrow institutional origins, with international research organizations (44%) and universities outside the study country (33%) predominating, followed by local universities (13%) and national research organizations (10%).

Table 1. Institutional affiliation of authors and lead authors of 39 published studies with gendered treatment of crop trait preferences and associated farmers' roles and responsibilities (N=number of studies).

Type of institution	Contributing to study (%)	First author (N)	First author (%)
National university	28	5	13
University abroad	49	13	33
National research organization	56	4	10
International research organization	69	17	44
National extension or development organization	15	0	0
Farmer organization	18	0	0
NGO	5	0	0

4.2 Goals or motivations for addressing gender and/or other socio-economic categories in studies related to trait preferences

The elucidation of farmers' trait preferences for a specific crop and context was not the primary objective for the majority of studies retained for this review (Table 2). While 21% of the studies were primarily targeting varietal acceptance issues, the majority of gender-specific trait preferences and requirements came from articles reporting on topics ranging from progress in participatory breeding through biodiversity, *in situ* conservation and seed system studies as well as ethnobotany and agricultural systems. However, the majority of studies (72%) were associated with ongoing breeding programs, with over a third of these also associated with seed dissemination activities. Thus, the major source of information regarding gender-specific trait

requirements comes from more applied research endeavors. No studies specifically focusing on seed dissemination, but not part of a breeding thrust, were found to report on gender-specific needs.

Table 2. Classification of study focus of 39 publications and frequency (%) of use of specific research methods to elucidate gender-differentiated trait preferences and associated crop responsibilities and roles by each type of study (N=number of studies; PRA= Participatory Rural Appraisal; FDG= Focus Group Discussion).

Study focus	N	PRA/ FDG (%)	Questionnaire or survey (%)	On-farm observation or selection (%)	On-station observation or selection (%)	Other methods (%)	Mean # of method classes
Participatory Plant Breeding	12	17	25	42	42	42	1.7
Varietal acceptance	8	25	50	50	13	25	1.6
Participatory Variety Selection	6	33	33	83	17	0	1.7
Biodiversity / *in situ* conservatio n	5	20	80	40	20	20	1.8
Product acceptance	4	25	50	25	0	50	1.5
Social science / ethnobotany	2	0	50	50	0	50	1.5
Baseline / system information	2	100	100	50	0	0	2.5

4.3 Methods and tools used

A wide range of methods were used to understand and describe gender-specific trait preferences and roles and responsibilities with regard to crop production and utilization as well as variety use (Table 2). Whereas participatory breeding efforts used extensive on-farm as well as on-station farmer observations and selections, Participatory Variety Selection, varietal acceptance and biodiversity studies emphasized on-farm observations more. However, all of the diverse studies used a range of PRA/FDG or questionnaire/survey methods, and others.

The "Other methods" class (Table 2) actually consists of a variety of methods, including choice and selection experiments, in depth interviews with key informants (Lope-Alzina, 2007; McElhinny *et al.*, 2007), characterizing farmers choice of varieties for home testing (Sperling *et al.*, 1993), and multi-stage testing (e.g. during the growing season, harvest, post-harvest home and culinary testing) (Baidu-Forson, 1997).

Also, within each study several different methods were used. Particularly studies using methods categorized as "Other", most often involved a range of methods.

4.4 Patterns of gender-differentiated trait preferences

a. Overall observations on gender-specific trait preferences

Gender-based differences were found for traits relating to all of the major domains across the value chain for a specific crop: production, processing and use, seed and market aspects (Table 3).

Table 3. Percent of studies providing background information on women's roles and responsibilities across the domains of crop production, use, seed or market activities within each study type, as well as providing information on domain-specific preferences (N=Number of studies).

Study Focus	N	Production (%)	Use (%)	Seed (%)	Market (%)	Mean # of category
Participatory Plant Breeding	12	83	67	33	25	2.1
Varietal acceptance	8	63	63	13	25	1.6
Participatory Variety - Selection	6	50	67	0	67	1.8
Biodiversity / *in situ* conservation	5	60	80	80	20	2.4
Product acceptance	4	0	50	0	25	1.0
Social science / ethno-botany	2	100	100	0	50	2.5
Baseline / system information	2	50	50	0	50	1.5

The review of trait preferences across all cases enables classifying traits that were mentioned specifically by men or by women only in individual studies (Table 4). As expected, women identified a host of post-harvest, processing, and food use aspects that were not mentioned by men, although one case of men specifically mentioning the suitability of a variety for a local dish was reported. Women more often also showed greater concern for traits associated with food security such as resistance to storage pests, earliness, pest and disease resistance, and multiple harvests. Women also identified harvestable products in addition to grain, such as leaves for food and stalks for fuelwood that were not mentioned by men. Traits that were only mentioned by men focused mostly on production-related traits.

Table 4. Traits noted specifically by women or by men in individual studies

Traits mentioned only by women	Traits mentioned only by men
Vigor	Pest resistance
Well adapted to a diversity of growing conditions	Adapted to intercropping
Leafiness	Yield/ha
Storage life	Suitability for local dish
Ease of dehulling	Resistance to waterlogging
Ease of threshing	
Quantity of useable flour	
Fuelwood quantity from stover	
Cooking time	
Taste, grain color	
Tall height for ease of harvest	

When looking at lists of traits that were mentioned more often or ranked higher by women then by men (Table 5) or the reverse (Table 6), traits related to production aspects showed diverse patterns, with women and men mentioning some of the same or similar traits, sometimes with differing weights, or completely differing traits, or environment-context specific differences. Women were more often concerned about ease of harvest, and sometimes more concerned with productivity under poorer soil fertility conditions, or labor requirements for weeding. Traits that men mention more often are mostly related to productivity, such as yield by volume, productivity *per se* (although rarely in first position), and productivity with overall low labor input, together with yield determinants such as cob size, grain size, and multiple cobs. Men more commonly identified market orientation and traits pertinent for marketing crop products than women.

Table 5. Traits mentioned more often or ranked higher by women then by men

Production-related traits	Post-harvest traits
Earliness	Food security
Ease of harvesting and transport	Threshability
Grain traits	Cooking quality
Pest and disease resistance	Less decortication, dehulling, milling losses
Multiple harvests	Market value
Requirements for weeding	Resistance to storage pests
	Straw quality for roofing
	Processing quality for locally marketed product
	Grain and leaf quality
	Medicinal properties
	Taste of specific dishes

Women, however, are clearly more specific in detailing preferences for post-harvest traits, from threshing to the taste of the food product. Specific other use of the crop, such as stover, or the leaves of grain legumes, or tuber crops also appear on this list (Table 5). Men, however, only rarely mention some post-harvest traits more often than women (Table 6).

Table 6. Traits mentioned more often or ranked higher by men then by women

Production related traits	Post-harvest traits
-	Storage life
Yield by volume	Good feed
Produced with little labor	Marketability
Productivity	
Agro-ecological adaptation	
Cob size, multiple cobs	
Grain size	

All the differences reported here were either significant, or when no significance test was possible, were of large magnitude, and thus indicative of major difference between men and women's appreciation for the same trait. To examine these differences in more detail and draw lessons for future gender-sensitive breeding work, we evaluated the cases with a view towards understanding under what circumstances or conditions gender-specific and differentiated trait preferences can be more likely expected.

b. Studies covering several sites with highly contrasting agro-ecologies: adaptation requirements for these different agro-ecologies are likely to be more important than the gender-based trait differences

The studies included in the detailed review differed widely in the geographical scope covered by the research. While some studies focused on a specific agro-ecology and production system, and focused the research on gender-related issues, other studies covered a range of countries, or different agro-ecologies in the same country. In these multi-site studies, farmers' preferences were studied over a range of production ecologies, and gender was usually an additional factor included in the studies. Actually several preference studies were excluded from this review, because they did not report on gender-differentiated results, even though farmers of different gender were included in the study, and numbers were reported in the methods section of the papers.

In cases that reported farmers' trait preferences for diverse ecologies and gender differences within the ecologies, the differences among trait preferences that can be explained by the specific adaptation requirements tended to be bigger and farther reaching for breeding programs than the differences due to gender-specific preferences within these ecologies (Chambers and Momsen, 2007; Efisue *et al.*, 2008; Christinck, 2002; Dorward *et al.*, 2007; Manzanilla *et al.*, 2014; Mulatu and Zelleke, 2002; Pingali *et al.*, 2001; Weltzien R. *et al.*, 1998).

As indicated in the introduction, a successful variety needs to be, above all, adapted to the production conditions that farmers are managing in the target areas of a breeding program. Good adaptation to the predominant production conditions and resistance to or tolerances of the most common stress conditions are essential for a variety to grow and be productive. It is thus not surprising that women and men working under similar production conditions and facing the same constraints prefer the same traits – whereas people working under different conditions may prefer a different set of traits. At the same time, there may also be cases where gender inequalities underlying patterns of land distribution or access to other productive resources lead to situations where women and men actually face different constraints, even within the same agro-ecology, or where the importance of existing constraints differs for women and men, respectively (see next section).

In some of the aforementioned studies, the fact that the qualitative research methodologies used for eliciting preferences between farmers from different agro-ecologies lead to differentiated results was actually used as an indicator that the methods applied were reliable, and did provide plausible results (Weltzien R. *et al.*, 1998) .

c. Situations where women and men farm under different growing conditions

Men and women from the same household have contrasting or complementary responsibilities in many societies. As a result, they have specific options and opportunities for raising income, either for their personal use, or for enabling them to fulfill their respective household responsibilities. One situation that was reported for several crops in different cultural contexts is that women may cultivate the same crop under very different growing conditions than those for men, with corresponding differences for adaptation requirements.

Maize in Mexico is one example: women cultivate maize in home gardens, intercropped with other crops, such as beans or pumpkins, or other vegetables, while men cultivate it in larger, more distant fields as sole crop for sale in the market (Chambers and Momsen, 2007). In this case, women actually planted varieties for specific uses and purposes in the home gardens, while men tended to grow maize for commercial purposes, often using hybrid seed. Hence, in terms of variety preference, women actually pursued their goal of being able to prepare special dishes for special occasions, using varieties that had the required specific characteristics. Women and men's appreciation for adaptation and growth characteristics differed widely, e.g. drought resistance, lodging resistance.

Beans in Rwanda provide another example (Sperling *et al.* 1993), where women grow the beans as an intercrop with maize or bananas, and they are the ones having knowledge and expertise in selecting for adaptation to these highly specific growing conditions. In this case, it is essential that the adaptation characteristics required for bean intercropping are included in the variety development and evaluation procedures, in order to achieve benefits for women producers.

The case of sorghum in southern Mali is one where women tend to focus on growing groundnuts, mostly at the end of a low-input crop rotation, with maize, sorghum or pearl millet. For a variety of reasons, many women also grow sorghum, mostly as an intercrop in their groundnut fields. They

thus require varieties adapted to intercropping, and to extremely low soil fertility, especially with respect to phosphorous availability. Both these traits have not been studied extensively; however, adaptation to low phosphorus availability is a trait for which sorghum shows considerably genetic variability, and thus good chances of achieving genetic gains (Leiser *et al.*, 2012).

Another such case is the case of pearl millet in western Rajasthan, a semi-arid state of India, where especially women of low caste families are often managing farmland on their own, as the men are involved in other economic activities. These women have only access to small plots of poor quality land, based on traditional patterns of land distribution, and thus require varieties that have adaptation traits suitable for such conditions, e.g. early flowering and high tillering potential (Christinck, 2002).

Furthermore, Rice in Mali, West-Africa, is grown in contrasting ecologies, upland, lowland and irrigated, with women predominantly cultivating rice in the irrigated and lowland conditions, while men are mostly cultivating in upland fields (Efisue *et al.*, 2008). Each agro-ecology requires different varieties with specific adaptation requirements.

d. Situations where women and men have different responsibilities for crop management and/or grow the crop for different uses

Responsibilities for different activities or phases of the crop production cycle may differ between genders in certain cultures, and thus result in specific preferences for varietal traits of a crop.

Women, being responsible for weeding rice, indicated more frequently the importance of its competitiveness for weed suppression (Gridley, 2002). Likewise, for women who are responsible for transporting and threshing pearl millet, the ease of transport and threshing becomes more important to them (Baidu-Forson, 1997).

Similarly, because men and women have different responsibilities for the functioning of their farm and household operations, they sometimes value different parts of the crops differently. For example, women in Ethiopia store, use or sell sorghum stover as cooking fuel (Mulatu and Belete, 2001) and wheat straw for roofing material (Nelson, 2013) and therefore reject newly bred short stature varieties as they would increase their workload, and/or reduce their income. Women in Burkina Faso use red sorghum grain to produce malt for local beer (vom Brocke *et al.*, 2010) and thus are interested in varieties with good malting and brewing characteristics, whereas breeding

has concentrated on white grain sorghum for food grain. In the northern part of Cameroon, women use cowpea leaves, either directly as food, or for sale, particularly during the hungry season (Kitch *et al.*, 1998), and the leaves of cassava are used by women farmers in Malawi (Chiwona-Karltun *et al.*, 1998). The husks of maize are an important source of income for women in some parts of Mexico. Men use maize stalks for feeding animals and women use the cobs as cooking fuel (Chambers and Momsen, 2007).

These differences may appear in preference studies – but may be easy to miss if such studies are not conducted, or if the scientists concerned do not appreciate the gender-specific roles and responsibilities for production, storage, processing, and marketing of the crop, or underestimate the value of by-products. It is thus highly advisable for breeding programs to gain at least a basic understanding of women's and men's roles and responsibilities within a specific production system, so that gender-specific trait preferences can be addressed in a more targeted manner. Likewise, setbacks or unequal distribution of benefits can be avoided, e.g. those resulting from breeding progress achieved for some traits at the expense of others.

e. Situations where a crop is grown only or predominantly by women or men

In some cultural and agro-ecological contexts, there are crops that are primarily grown either by women or by men, in which case the knowledge and expertise for crop management and related trait preferences may be unevenly distributed between genders.

Several studies in this review have focused on women's expertise for crops for which they are predominantly responsible, such as beans in Rwanda (Sperling *et al.*, 1993), Kersting's groundnut in Benin (Assogba *et al.*, 2016), cassava in Malawi (Chiwona-Karltun *et al.*, 1998), and banana in Uganda (Gold *et al.*, 2002a).

However, we were surprised to find no preference studies focusing on some of the classical 'women's crops', like traditional vegetables in Africa or Asia, groundnut or Bambara groundnut in many countries of West Africa, or finger millet in many countries of eastern Africa. Moreover, the decline and threatened disappearance of crops predominantly cultivated by women, such as African Rice (*Oryza glaberrima*) (Teeken *et al.*, 2012), require particular attention.

In some situations, there is a tendency towards increased responsibility of women for growing crops formerly grown predominantly by men, or by women and men together. Thus, the above-

described gender-specific focus on growing certain crops is not static and may change over time; this process may take place at a large scale, or be limited to certain geographical areas or population groups. Where male farmers out-migrate for labor, for example, leaving women primary responsible for cultivating crops or managing the entire farm, these women's varietal trait preferences may differ from those of men growing the same crop in the same area, based on different access to productive resources and their position in society. Examples were described for maize in Mexico (Chambers and Momsen, 2007) and in South-west China (Song *et al.*, 2006). To ensure that they can all benefit equally from breeding progress, particular attention to these women's preferences and needs is required in such situations.

f. Post-harvest processing and food preparation: often an area of women's expertise

Most studies of gender-differentiated trait preferences report differences between men and women regarding their knowledge and skills at differentiating varieties for different food uses, for quality traits related to post-harvest processing and food preparation, as well as to quality of the prepared meals.

In most cultures, it is mainly women's responsibility to prepare the food for the family. Depending on the crop in question, this may include storage and post-harvest processing, as well as cooking itself. It is thus not surprising that women tend to pay close attention to all plant traits that contribute to efficient processing and preparation of high quality foods from the products harvested in the fields.

In a breeding program in Mali focusing on sorghum, for example, women and men were concerned about the percentage of grain harvested from a panicle and a high threshing percentage; that means avoiding losses from poor grain filling due to terminal drought, or insect pests; but also from shattering and poor opening of the glumes. The following steps (post-harvest) are clearly the women's domain: they are looking for varieties that have hard grains, so that the losses during the decortication process are as low as possible, even if it may require somewhat more time to do the work. The same grain hardness tends to also render grains less susceptible to storage pests, and thus ensure that the harvest can last until the next season. In addition, the women are concerned about the result of the milling process: the flour-to-semolina ratio is important for balancing food between different meals. Of further specific importance are the flour's capacity for swelling, and the consistency of the cooked food. This explains why grain yield of a variety that does not have these qualities might be higher at harvest, but in actual fact lower in

terms of food, if there are serious losses during threshing, storage, decortication, milling or cooking. Hence, a sorghum breeding team in Mali coined the term 'food yield' (Diallo, Isaacs and Weltzien, in prep.), to incorporate the entire process of post-harvest processing into the variety evaluation process.

In looking through the cases that we could maintain for this review, very similar concerns were raised by women for many of the cereal crop cases, e.g. sorghum in Burkina Faso (vom Brocke *et al.*, 2010), sorghum in Ethiopia (Mulatu and Belete, 2001), sorghum in Ghana (Kudadjie, 2006), maize in Ethiopia (Mulatu and Zelleke, 2002), maize in Mexico (Lope-Alzina, 2007), maize in Mali (Defoer *et al.*, 1997) as well as rice in Ghana (Dorward *et al.*, 2007).

It is actually surprising that research into food processing and varietal characteristics, even in developing countries that may not have grain processing industries for these locally produced crops, focuses more regularly on market-oriented traits, rather than traits important for local food processing. This is an area of gender-sensitive research that requires a lot more attention by breeders and associated food scientists, especially in production systems where the crop is predominantly produced for home consumption or local marketing, and where it is of high relevance for food and nutrition security.

Even though women tend to be primarily responsible for post-harvest processing and food preparation in most societies, and are thus likely to be more knowledgeable and assertive about relevant traits, these traits can also be of utmost importance to male farmers, e.g. if the crop is mainly used for home consumption. Thus, in many of the cases studied, varietal deficiencies for traits of relevance for local storage, processing and consumption can be directly linked to non-adoptability of new varieties.

g. Family food security: often a particular concern of women

As indicated above, women are responsible for preparing the family food in most instances. In many cultures, however, men are in turn responsible for providing the necessary grain, and possibly other ingredients, so that women can prepare the daily meals. There are, however, situations when the men cannot provide grain to satisfy everyone, or not in sufficient quantity, as they may have to ration the stocks to make sure they last long enough. This can be the case if they do not own sufficient land, if the harvest was poor, if stocks were destroyed, or if they migrate

out for finding jobs elsewhere. For any of the cases, it is usually women who bear the brunt, especially if there is not sufficient grain to prepare food for their younger children.

Many of the preference studies show or indicate this specific concern of women for food security of their families. For beans in Ethiopia, the importance of food security was mentioned directly by women (Assefa *et al.*, 2014), while in an earlier study, women highlighted the importance of being able to harvest beans multiple times (Assefa *et al.*, 2005). Similarly, in Malawi, discussions about legumes that were being tested for improving soil fertility, the importance of these crops to contribute to improving food security directly was raised by women (Kerr *et al.*, 2007)

Another trait that farmers usually associate with food security, and being able to start harvesting something to cut the 'hungry season' short, is earliness. In several studies, earliness was mentioned solely or more frequently by women, such as for maize in Kenya (De Groote *et al.*, 2002), maize in Ethiopia (Mulatu and Zelleke, 2002) or for quinoa in Ecuador (McElhinny *et al.*, 2007). For sorghum in Mali, the earliness is also an important point of discussion, with gender differences due to the different types of fields that can be grown (Diallo *et al.*, in prep.; Almekinders and Hardon, 2006)

Production even in bad years was specifically mentioned by women in Mexico for maize (Smale *et al.*, 1999). Likewise, production under poor soil fertility conditions was raised as a concern by women from the Savannah zone in Ghana, growing rice (Dorward *et al.*, 2007), as well as production under a variety of other stress conditions, e.g. for beans in Rwanda (Sperling *et al.*, 1993) or for bananas in Uganda (Gold *et al.*, 2002a,b).

The analysis of the case of cassava in the central part of Malawi shows clearly the importance of a detailed understanding of food security issues in relation to crop characteristics (Chiwona-Karltun *et al.*, 1998). In this particular case, the bitterness of cassava roots prevented theft from the fields, and allowed women, who are responsible for producing and processing it, especially in poorer families, to better manage the harvest and harvestable stocks. Hence, to ensure food security for the family, bitter cassava varieties were preferred by the women even though this required of them a tedious process of ensuring that the bitter (and toxic) compounds are removed from the final food products.

This review indicates that women's specific knowledge of, responsibility for and experiences with family food security, and actually health through good nutrition, is often overlooked or factored in very late in the variety development process. Especially crop bio-fortification efforts, but also other breeding programs targeting improvements in food security, would benefit from involving women from their target regions early on in the breeding cycle.

5 Conclusions

5.1 Gender-differentiated trait preferences, influencing factors and implications for breeding programs

In the previous section, we presented examples of gendered trait preferences in agricultural crops including traits that were more commonly preferred by women than by men, and *vice versa* (Section 4.4.a). We further identified several influencing factors shaping patterns of women's and men's varietal trait preferences in crops (Sections 4.4.b-g). An important factor leading to women and men having *similar* trait preferences were situations where they faced similar constraints, e.g. site-specific abiotic or biotic stress conditions. The same could also be true for other types of constraints or requirements, e.g. where quality standards are established and compulsory for all producers in a particular value chain.

At the same time, there are factors leading to women and men having *different* trait preferences, e.g. in situations where they farm under different conditions, where they have different roles and responsibilities for crop cultivation or different production goals, or where a crop is grown only or predominantly by either women or men.

Women's special expertise regarding traits of relevance for post-harvest processing and food preparation as well as their often reported concern for traits relating to family food security are in fact special examples of different roles and responsibilities of women and men within farming and food systems. The fact that post-harvest processing and food preparation is part of women's chores in rural households across many different cultural contexts makes it appear somehow

"natural" that the related knowledge is predominantly held by them, or that they are more aware of problems and constraints that may occur in this particular domain.

However, where gender roles are more flexible, or change because of ongoing societal transformations, this apparent "general rule" may not always be true. Therefore, crop-breeding programs should rather rely on clear diagnostic work for the crop(s), target region(s) and trait(s) in question, than on assumptions of gender roles and responsibilities.

5.2 Integrating women's and men's trait preferences into varieties for improved family benefits

Several of the studies have specifically examined decision-making within a family with regards to planning for crops and varieties to be cultivated, where and when, and found that in most contexts there is considerable discussion and negotiation happening about these issues (Chambers and Momsen, 2007; Diallo *et al.*, in prep.). This indicates that men's and women's areas of knowledge and expertise tend to be integrated in family decision-making, and that they can be highly complementary. This is good news for plant breeders who are concerned about increasing the diversity of varieties that their programs may have to generate to satisfy women's specific trait preferences. In many of the cases analyzed here, women communicated specific preferences for varietal traits of a crop, with some priority concerns being oriented towards post-harvest processing, storage or food quality issues. As shown above, these traits are essential for local adoption and use of modern varieties, in a similar way that varieties used for industrial food processing have to comply with specific quality criteria.

In situations where food self-sufficiency and nutritional quality of diets are major concerns, understanding and addressing the relevant quality requirements, e.g. for storage and local food processing, is of vital importance. While this may imply considering additional traits in the selection procedure, it usually does *not* mean creating specific varieties for use by women only. Considering these local quality requirements in further breeding efforts and variety release decisions will improve chances that the newly developed varieties can be widely adopted by the target groups of farmers, and generate the benefits envisaged at farm and household levels.

5.3 Importance of understanding the agronomic and socio-economic context

Results presented in sections 4.4.c, d and e highlight that deepening the understanding of gender-specific differences regarding conditions, roles and responsibilities for the cultivation, use and marketing of a crop can guide plant breeders towards addressing traits in a more systematic manner, aware of gender-specific preferences for varietal characteristics. For example, women may be interested in varieties that are better adapted to late sowing, because they cannot access equipment for land preparation at earlier dates, or in varieties that are adapted to poor soil fertility conditions. Gender-sensitive research in the production systems of target areas of a breeding program will help assess whether other groups of farmers may face similar constraints, and thus justify a program addressing these constraints for a reasonably large number of farmers.

Similarly, breeding methodology research can clarify whether breeding for certain stress conditions will have negative consequences for genetic gains under non-stress, or other stress, conditions, and if so eliminate them from the set of goals addressed. Depending on the degree of variation in site conditions and related trait preferences, this type of research could also help assess what degree of decentralization might be beneficial. Furthermore, options for farmer participation in the variety development process can be explored based on these findings.

5.4 Methodological issues

Most of the studies reviewed used more than one method to learn about trait preferences of farmers in a gender-differentiated manner. Some studies repeated their observations over two or more seasons. This flexibility is useful, as much of farmers' knowledge and expertise is part of their daily life and 'way of doing things'; as such, it can be described as 'tacit knowledge' that is embedded in practices, tools and procedures (Polanyi, 1966). Very often, it is not obvious to the farmers how much the researchers do not know about the 'basic aspects of life and farming'. Likewise, it may not always be clear to the researchers that they work with many unproven assumptions, e.g. on production conditions and goals, that may not correspond to the actual situation of (all) farmers.

Hence, learning about gender-differentiated trait preferences, even in a formal research setting, requires iterative and flexible approaches, using participatory methodologies that focus on dialogue, e.g. by visualizing, showing, observing and discussing (Christinck *et al.,* 2005), rather than on formal surveys alone. Such joint learning, focusing on developing a shared understanding of the problems and constraints that are to be addressed in a breeding program, can be facilitated through collaboration with social scientists and communication experts, especially if appropriate tools and options for documentation are being used, so that the results can be shared more widely.

One further conclusion (from section 4.4.f) is that research on consumer demand is scarce, especially for crops and crop-derived food products that are important for food security of rural families and require on-farm (or local) processing. While methods for such research are widely available, they are not commonly used in the context of priority setting for plant breeding programs in developing countries, resulting in a situation that basic quality requirements for the main use of the targeted crops remain unaddressed. This issue is also raised by Nelson (2013), stating: "Millions of dollars (Gallo *et al.,* 1996) and countless hours are spent each year in developed countries on understanding consumer demand and marketing for agricultural products but relatively fewer funds are funneled into agricultural marketing in a developing country context."

While trying to identify studies and reports to be included in our review, we found that even if gender-disaggregated data were collected in baseline studies or participatory variety evaluations, the reporting of the results was often not clearly differentiated by gender, or lacked a statement as to the level of significance of the findings. This seems to be indicative of a lack of interest in understanding gender differences in varietal trait preferences, or underestimating their importance. However, as stated again by Nelson (2013): "There is significant potential to increase production on small-scale farms with improved technology such as disease resistant varieties, soil fertility management, and weed control. But, without addressing gender-specific constraints and preferences, the full potential may never be reached (Klawitter *et al*., 2009)."

6 Way forward

The review of literature presented here found only relatively few cases where there was a systematic follow-up, or follow-through, by a breeding program based on improved insights about gender-differentiated trait preferences. However, gender-sensitive plant breeding research is being done – and could become a key to greater effectiveness of breeding programs, overcoming the common frustration of low adoption of newly bred varieties.

Some examples of re-orientation of breeding programs to include selection for locally identified grain quality traits were documented in Burkina Faso (vom Brocke *et al.*, 2010) and are known, but not documented, in Mali (Abdoulaye Diallo, personal communication, September 2016). They are proceeding through to seed production of varieties with high flour yield and quality, as preferred by women, and large-scale commercialization through farmer organizations (vom Brocke *et al.*, 2014).

Other examples of how gender-differentiated trait preferences were studied and/or addressed in breeding programs certainly exist, but are not yet published in scientific literature. A joint effort to document such experiences, e.g. on changes in selection strategies and related outcomes, could help increase the amount of evidence available, and make it more substantial.

A potential dilemma is that breeding programs tend to reduce the number of traits to be included in a selection program, in order to achieve significant genetic gains, whereas needs and preferences of farmers are diverse. It is often assumed that the development of varieties for more diverse user preferences would require separate breeding efforts, and thus additional budgets.

However, several initiatives have been undertaken to develop methodological alternatives to overcome at least partly such resource bottlenecks; even though not all of them addressed gender-differentiated trait preferences, they can pave the way towards more inclusive and diverse breeding methods.

Adjusting the pool of breeding materials, for example, could help ensure that important traits for adaptation and use, which are relevant for women *and* men, are well represented in parental material – including agreed upon ‘must-haves’ for new varieties for a specific target region.

Selection can then focus on the key traits targeted for improvement (Weltzien and Fischbeck, 1990; Ceccarelli, 1994; vom Brocke *et al.*, 2002; vom Brocke *et al.,* 2010).

Population improvement, using recurrent selection techniques, can serve as a basis for decentralized development of open-pollinated varieties, integrating different sources of parent germplasm (Haussmann *et al.*, 2012). For self-pollinated crops, several reports have been published about rapid gains achieved by involving farmers in a participatory manner, early in the breeding process (Ceccarelli *et al.*, 2001; Witcombe *et al.*, 2005).

The genetic gain that can be expected for a specific trait depends on selection intensity, heritability, and the genetic variance of the trait expressed in the material under selection. Depending on the trait, this may require different methods for observation, and, depending on the heritability and variance, diverse costs.

Breeders, in collaboration with interdisciplinary research teams and farmers, or eventually other actors involved in value chains, could routinely discuss and map selection decisions for specific traits or trait combinations. These decisions include choice of breeding materials, options for using genomic selection tools, inputs from phenotyping platforms, strategies for identifying and discarding unwanted traits or plant types in early stages, and opportunities for decentralization and collaboration (e.g. vom Brocke *et al.*, 2010). This mapping of trait selection over the entire breeding cycle would embody orientation and regular re-orientation of a program to effectively address the diverse trait preferences of farmers, women and men, working under diverse conditions for a variety of goals.

Working with farmers in larger networks of cooperation with researchers is a research theme just starting to be explored (Dawson *et al.*, 2011), which could lead to breakthroughs in addressing this dilemma of diversity of needs while targeting specific genetic improvements.

New breeding techniques for enhancing specific traits, such as ‘genome editing’, genomic selection or marker-assisted back-crossing, could best contribute to achieving genetic gains for specific traits more rapidly, efficiently or effectively, if they form part of such integrated approaches. For farmers to benefit, a thorough and well-founded knowledge will be required of

the traits or trait combinations for which improvements are to be achieved, and not at the expense of other relevant traits or with new or unknown associated risks. This would actually require a sound methodology and gender-inclusive participation structure when planning for crop development programs at various levels – internationally, regionally, nationally, and locally.

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Annex

TABLE FOR SUMMARIZING CONTENT OF KEY STUDIES FOR THE REVIEW: GENDER DIFFERENCES IN VARIETAL TRAIT PREFERENCES

Trait Category: (3=Gender diff. trait preferences, 2=Trait prefs. & some gender discussion, 1=Trait but no gender information)

Methodology/Context: (3=interesting/innovative method, 2=interesting context, 1=weak)

Key question for selecting the study for further evaluation: Does the study report on gender-differentiated trait preferences?

(Yes/no – continue only if the answer is YES; continue also if trait preferences are reported for one group only, e.g. women or men)

Basic information	
Title	
Author(s)	
Year of publication	
Date of study (=data collection)	
Region(s) included (e.g. Central America, Sub-Saharan Africa)	
Country(ies) included	
Agro-ecological region(s) included	
Type of farming system	
Crop(s) covered	
Institutional setting (e.g. types of partners involved in project/study)	
Professional facilitation/researchers trained in social science methods involved? (yes/no)	
Relaed to breeding program? (yes/no)	
Related to seed dissemination program? (yes/no)	

Analysis of methods used	
Unit of analysis (individuals, households, groups, communities, etc.)	
Number of units in the study (N)	
Size of populations/groups to which the study refers (e.g. in the case of representative samples taken from a larger group: size of this group)	
Differentiation for other socio-economic categories (other than gender, e.g. size of landholding, poverty, education, owner/operator versus laborer, ethnic group, etc.)	
Type(s) of data collection methods used (e.g survey, ethnography, participant observation, PVS, PRA, on-farm or on-station selection etc.)	
Sex/gender differentiated data presented for (yes/no):	
Access to resources (e.g. size of landholdings, soil quality, irrigation)	
Production process (e.g. labor or other resource input)	
Type(s) of use	
On-farm processing	
Value chain(s) and/or marketing channels used	
Control over end-product(s) and associated benefits	
Others (which?)	

Analysis of results relating to trait preferences	
Trait preferences identified in the study (list)	
Traits preferred by both men and women (list)	
Traits preferred by men (list)	
Traits referred by women (list)	
Does the study provide a ranking or information on priorities among traits? (yes/no)	
If yes, is this ranking gender disaggregated? (Yes/no)	
Preference ranking of traits preferred by men (list)	
Preference ranking of traits preferred by women (list)	
Does the study also relate these trait preferences to other socio-economic categories mentioned above? (explain/list results)	
Have the results been used in a breeding program? (if yes, how/in which way)	
Have the results been used for seed dissemination, e.g. to choose varieties for dissemination that target preferences of women/men)?	
Does the study report on outcomes/benefits/impacts of using information on gender-differentiated trait preferences in a breeding program? (if yes, which outcomes/benefits/impacts)	