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Participatory Variety Selection for enhanced promotion and adoption of improved finger millet varieties: A case for Singida and Iramba Districts in Central Tanzania

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ABSTRACT

Participatory variety selection (PVS) is an approach which provides a wide choice of varieties to farmers to evaluate in their own environment using their own resources for increasing production. It enhances farmer's access to diverse crop varieties, increases production and ensures food security and helps faster dissemination and adoption of pre and released varieties. It allows varietal selection in targeted areas at cost-effective and timely manner and helps promotion of community seed production and community seed banks. Therefore, a variety developed through PVS usually meets demand of different stakeholders. Farmers in Singida and Iramba districts in central Tanzania were found to be growing land races which were low yielding, long maturing, drought and disease susceptible, as no variety had previously been released in Tanzania. Through PVS a broader choice of varieties that matched farmer needs in adaptation and quality traits was offered for evaluation. As such PVS was used to introduce, evaluate, release and promote for adoption finger millet varieties in Central and Northern Tanzania. Farmers selected and adopted new varieties of a higher utility (a combination of improved agronomic traits, higher yield, and improved quality). Through PVS Tanzania released her first finger millet varieties (U15 and P224). Adoption of the varieties was very high as farmers associated with the varieties; and affordable high quality seed was made available as Quality Declared Seed (QDS) produced by the target farmer groups. Preferred traits differed between the gender groups; women preferred risk averting traits like short duration, drought tolerance, compact heads and disease resistance while male preferred market related traits (high yield, brown colour and big head.

Keywords: *Eleusine coracana*, farmer preferred traits, Participatory Variety Selection, varieties, gender, Tanzania

RÉSUMÉ

La sélection participative de variétés (SPV) est une approche qui offre un large éventail de choix de variétés aux agriculteurs, à évaluer dans leur environnement en utilisant leurs propres ressources pour l'augmentation de la production. Elle améliore l'accès des agriculteurs aux diverses variétés de cultures, augmente la production, garantit la sécurité alimentaire et favorise la diffusion et l'adoption plus rapides des semences et des variétés développées. Elle permet la sélection variétale dans les zones ciblées de façon rentable, en temps opportun et contribue à la promotion de la production communautaire de semences et des banques de semences communautaires. Par conséquent, une variété développée par l'approche SPV répond habituellement à la demande des différents acteurs. Les agriculteurs des districts de Singida et Iramba, au centre de la Tanzanie cultivent des cultivars locaux à faible rendement, à longue cycle, sensibles à la sécheresse et aux maladies, ceci à cause de l'indisponibilité de variétés améliorées. Grâce à l'approche SPV, un choix plus large de variétés adaptées aux besoins des agriculteurs en matière d'adaptation et de qualité a été proposé pour être évaluer. Ainsi, une telle approche a été utilisée pour introduire, évaluer, diffuser et promouvoir l'adoption des variétés de mil au centre et au nord de la Tanzanie. Les agriculteurs ont choisi et adopté de nouvelles variétés d'une plus grande utilité (une combinaison de caractères agronomiques améliorés, rendement plus élevé et qualité améliorée). Grâce à la SPV, la Tanzanie a eu à certifier et diffuser ses premières variétés de mil (U15 et P224). L'adoption des variétés était très élevée, vu que les agriculteurs étaient associés au processus de sélection des variétés; et des semences de haute qualité et à moindre coût ont été diffusées sous forme de semences de qualité certifiées (SQC) produites par les groupes d'agriculteurs cibles. Les traits préférés différaient selon le genre. Ainsi les femmes préfèrent les traits de moindre risques tels que la courte durée, la tolérance à la sécheresse, les têtes compactes et la résistance aux maladies tandis que les hommes préfèrent les traits qui ont rapport à la commercialisation (rendement élevé, couleur brune et grosse tête).

Mots-clés: Eleusine coracana, traits préférés des agriculteurs, sélection participative de variété, variétés, genre, Tanzanie

INTRODUCTION

Millets are grown in harsh environments and the performance of the variety is linked to its ability to adjust to fluctuating edaphic and climatic situations. Subsistence farmers growing millets and other minor crops in unfavorable environments use low levels of inputs and have not benefitted much from high yielding variety (HYV) technology (Gowda *et al.,* 2000). Given the uncertainty in these dryland areas, farmers' concern is not so much to increase productivity but to avert complete failure. In Sub-Saharan Africa yields of finger millet (*Eleusine coracana* L. Gaertn) are low and a number of production problems have been cited which include: lack of improved varieties, little research emphasis given to the crop, non-adoption of improved technologies, poor attitude to the crop, diseases like blast, lodging and moisture stress in dry areas (Tsehaye and Kebebew, 2002; Andualem, 2008; Degu *et al.,* 2009; Molla, 2010). A number of improved varieties of finger millet have been released by the different research centers in the region but have not been adopted by the farmers. This is because the varieties were not evaluated in target areas and were released without the participation of farmers, as a result the farmers do not have sufficient information about both agronomic practices and their economic importance (Fentie, 2012).

The usefulness of the participatory variety selection (PVS) as an approach for identifying cultivars for harsh environments and acceptable to resource-poor farmers has been demonstrated (Gowda *et al.,* 2000). A study carried out in India using six finger millet varieties with 150 farmers documented the effectiveness of such an approach in identifying cultivars for meeting the requirement of the resource-poor farmers under real farm situations (Courtois *et al.,* 2001).

Participatory varietal selection arose from the realization that farmers were not using varieties developed and tested on research stations which did not work in their context. So farmers continued to grow old, unproductive varieties prone to pests and diseases. The objectives of PVS described in this paper are to:- prioritize finger millet production constraints and their potential solutions, identify suitable technologies in various farming environments, and gain greater insight into farmer perceptions, preferences and knowledge of improved varieties and technologies, build the capacity of extension, NGO and farmers to be able to choose suitable technologies and delivery systems that work to improve the household welfare, enhance faster promotion of well adapted improved varieties with desirable agronomic and market characteristics, and solicit farmer feedback for planning agricultural research.

Participatory varietal evaluation and selection has been conducted in many crops like rice (Sthapit *et al.,* 1996), common bean (Kornegay *et al.,* 1996) and barley (Ceccarelli and Grando, 2007; Fufa *et al.,* 2010), finger millet (Gowda *et al.,* 2000) and sorghum (Vom Brocke *et al.,* 2010), in a number of countries like Ghana, Bangladesh, India, Nepal and Bukina Faso where improvements in quality and yield have been startling. Courtois *et al.* (2001) evaluated the effect of participation of farmers by comparing only the rankings of varieties by farmers and breeders at the same locations and reported a strong concordance between farmers and breeders in environments that had been producing contrasting plant phenotypic performance in rice. Cleveland *et al.* (1999) and Danial *et al.* (2007) reported that farmers' selection criteria vary with environmental conditions, traits of interest, ease of cultural practice, processing, use and marketability of the product, ceremonial and religious values. Tremendous increases in productivity have been achieved over the local cultivars in many crops across countries and these have been associated with other improvements like resilience and good quality. The potential for participatory varietal selection is therefore huge as it could be applied to all farming systems, all major crops, all types of farmers, and all countries. Participatory varietal selection involves the testing of a new intervention - a crop variety - with farmers in the farmers' fields which overcomes the limitations of traditional, on-station testing systems. Other interventions can be tested that are synergistic with new crop varieties such as improved crop agronomy, including seed priming and crop protection.

The most important reason why new cultivars may be attractive is that current genotypes have some shortcomings. This can be with regards to particular environmental conditions, farm management practices, quality demands, suitability to trade, etc. Also, agricultural crops are being cultivated in a continuously changing biophysical and socio-economic environment. Therefore search for better characteristics under prevailing conditions such as better taste, greater yield, better disease tolerance, and good response to organic fertilizer is essential. Local germplasm or germplasm from regions with a similar environment may be suitable for immediate cultivation. Cultivars from regions with a very different environment are probably less suitable for cultivation. They may for instance be undesirable because of a different taste or poor disease tolerance. Such an undesirable trait can be easily determined with a simple evaluation experiment in which new and old cultivars are compared. A very important advantage of PVS is that the adoption of new cultivars is much faster than under the formal system, in which farmers are confronted with only a very restricted range of new cultivars (Witcombe and Joshi, 1996). Also the spread from farmer-to-farmer through the local seed system can be very fast, thus guaranteeing a further good adoption.

A major constraint to adoption of improved crop varieties, cited by many studies, is inadequate access to seed. Seed accessibility has five major components that may present constraints to farmers. One of the major advantages of PVS is the rapid dissemination of varieties. Whereas through the formal system, it may last more than 10 years before a new breeding product reaches villages, PVS cuts short formal procedures and simply lets farmers decide whether germplasm is acceptable or not.

Any participatory research methodology should consider the importance of gender (Bellon, 2001). From a practical point of view, this means that researchers should be sure to include participants who play different roles within households, such as women, children, spouses, parents, and female heads of households. This also means paying special attention to interactions among household members. Depending on where the research is being done, it may be necessary to form same-sex groups (i.e., groups of only men or women), since in mixed groups women may not participate at all. In other contexts, however, mixed groups may provide an excellent opportunity to elicit gender differences and concerns. Even in individual interactions it may be necessary for men to interview or interact only with men, and for women to interact only with women.

In the past, agricultural research focused mainly on male farmers and assumed that all household members shared the same goals, had the same access to resources and outputs, and faced similar constraints. Now it is clear that in most cases this view is incorrect. Just as differences between farmers and households may be attributed to differences in access to resources, knowledge, and information, differences within households also exist and may be attributed to different factors. Household members may have diverse responsibilities, perform different activities, and have varying workloads and access to resources. They may also have conflicting interests. These differences can be particularly striking in Africa where household organization can be extremely complex (Doss, 1999).

The usefulness of the participatory approach for identifying cultivars for harsh environments, which are difficult to replicate in research stations, has been recognized by the crop breeders (Baidu-Forson, 1997; Joshi and Witcombe, 1996; Sthapit *et al.,* 1996; Thiele *et al.,* 1997). Participatory varietal selection has four steps: (1) a participatory rural appraisal to identify client needs in new varieties, (2) a search for suitable varieties to match those needs, (3) on farm variety testing with farmers, and (4) wider dissemination of farmer-preferred varieties. The process of participatory varietal selection is not commodity specific and is applicable to all crops in all agricultural systems but has been extensively used in semi-arid systems, smallholder rain fed dry/

cold farming system and wetland rice based system (Witcombe *et al.,* 1996). The wider adoption of this improved method of testing new varieties would change policy on varietal release and provide a greater choice of improved varieties for low-resource farmers that significantly improve their livelihoods. Participatory Variety Selection was used to introduce, evaluate, release and promote for adoption of finger millet varieties in a number of countries in East and Southern Africa. The paper presents a case in Central Tanzania where the intervention was conducted between 2009 and 2015. Not many well-planned studies have been reported on the participatory approach of varietal selection and crop improvement (Gowda *et al.,* 2000). This paper discusses selected results in Central Tanzania where PVS was used as an approach in the identification, evaluation, release and promotion of finger millet varieties. In Tanzania finger millet is a major staple crop among the resource poor farmers.

MATERIALS AND METHODS

Eight finger millet genotypes, Acc #14, Acc#32, KNE 628 KNE 688, KNE 814, P224 and UFM 149 selected from regional Multi Evaluation Trials (MET) for high yield and resistance to blast and a local Tanzania variety were evaluated for adaptation in 15 farmer fields each in Singida and Iramba districts of Central Tanzania. The trials were distributed among female and male farmers.

Ranking of preferred traits.

The criteria farmers use in selecting suitable varieties depends on the existing constraints and opportunities. Therefore, the first step is to identify and prioritize production and market constraints. Focus Group Discussions (FGD) sessions using pair wise ranking matrix and problem-causes analysis was used to prioritize constraints, and identify potential solutions, respectively. Participatory varietal selection (PVS) takes into consideration a number of traits in addition to yield, and they include: drought tolerance/ resistance, earlier maturity, ear type (usually compact is preferred) and size, grain size and disease resistance. Using 10-15 farmers in focus group discussion (FGD), production and market constraints were identified and prioritized in the project areas. In Tanzania, groups representing the main finger millet growing areas of Singida/Iramba, Rombo and Sumbawanga were requested to list and prioritize the traits using a scoring scheme (1=very poor; 2=poor; 3=moderate; 4=good; 5=very good) to identify most preferred traits (criteria) for rating the varieties on test.

Ranking of varieties

Field days were organized in the different on-farm PVS trials when the crop was at physiological maturity where farmers were requested to rank the varieties based on the traits they had previously prioritized. Farmers were divided by gender (Women, Men and both sexes) and each gender group subdivided into smaller groups consisting of 10-15 farmers. Each smaller group was given a template containing variety list along the vertical column and the different traits on the horizontal column. The varieties were represented by numbers to avoid bias and/or selection of the varieties already know (local). Varieties were ranked for each character (for instance, yield, taste, disease resistance), and base the actual selection on the average of all separate rankings. Scores from the different groups are averaged per gender, per farmer field and scores from the region averaged per group to give the scores per region. After harvest, data like grain color, threshability, quality of the different foods from the grain was taken and added to the pre-harvest data to form the final scores. Final scores were used for ranking the varieties with the one with the highest score being the best and the one with the lowest the least preferred.

Quantitative data

Data was taken by the extension staff and the researchers during the course of the trial. This include: Days to flowering (days), plant height at maturity (cm), Agronomic score (score) and grain yield (t ha^{-1}). The quantitative data was subjected to Analysis of Variance (ANOVA) using the Genstat program, using farmers as replicates district as the treatment for farmers in the different districts, while Female and Male farmers formed the different Gender treatments. Both quantitative and qualitative data were used to generate means. These data were used to substantiate the farmer PVS data in the final scoring and selection.

GGE (Genotype by Genotype x Environment) biplot was constructed by plotting the first Principal Component (PC1) yield scores of the genotypes and the environments against their respective scores for the second principal component (PC2) (Yan *et al.,* 2007) using the Meta-Analysis function of the Genstat program. The “which-won-where” view of the GGE biplot (Yan *et al.,* 2000) is an effective visual tool in mega-environment analysis because the biplots display both G and GE, which are the two sources of variation that are relevant to cultivar evaluation (Gauch and Zobel, 1996; Yan and Kang, 2003).

RESULTS AND DISCUSSION

Identification of farmer preferred traits

Although there were slight variations across the districts in finger millet trait preferences, the traits recorded as very important across the districts were high yield, large fingers and marketability (Table 1). Those reported as important were drought resistance, early maturity, good taste, large grains and grain color. There were relatively fewer traits in the areas most likely due to the fact that no improved varieties were available and farmers were using their local varieties. The low rating of disease resistance trait is perhaps due to unfamiliarity with the impact of blast on finger millet yield, as evidenced by farmers in Sumbawanga who did not rate disease as they were not familiar with blast. After identification, the Farmers ranked the traits and placed yield and early maturity as number one with 8 points; drought tolerance came second with 7 points followed by panicle size and good taste in the fourth position with 6 points (Table 2). Good color (red), followed by panicle shape (compact) and good fermenting ability came next. Biotic stresses, blast and striga resistance came last, most likely because farmers at that time were not aware of blast, whose symptoms they sometimes mistook for effects of drought or signs of maturity in the case of neck and finger blast; on the other hand no cases of Striga in finger millet had been reported in the Central and Northern regions of Tanzania, as a result farmers did not see it as a threat to finger millet production. High grain yield appeared in all comparisons except for drought and drought in all except for early maturity. Early maturity appeared in all the comparisons except in for high yield and large panicles.

Table 1. Results of Focused Group Discussions (FGDs) on preferred finger millet traits under HOPE project finger millet production zones of Singida/Iramba, Rombo and Sumbawanga, Tanzania

Finger millet traits	Score[1]			Mean score
	Singida/Iramba	Rombo	Sumbawanga	
High yield	4	5	5	4.7
Drought resistance	5	4	3	4.0
Early maturity	3	4	5	4.0
Marketable	5	4	-[2]	4.5
Good taste	3	4	-	3.5
Diseases resistance	1	4	-	2.5
Big fingers	-	5	4	4.5
Large grains	-	3	4	3.5
Grain color	-	4	3	3.5

[1]Scoring scale: 1=not important; 2=minor importance; 3=moderate importance; 4=important; 5=very important. [2]Not scored

The results are in agreement with the matrix ranking by Monyo *et al.* (1998) which described a case of pearl millet in Namibia. Information had to be obtained from groups that are knowledgeable, so, two groups were formed. One group was formed of 10 older men, and another group of seven younger women.The women were more knowledgeable on food quality and processing traits. Farmers were asked to list all positive traits they would like to include in a future variety. Farmers, extension staff and researchers then went into the field to evaluate varieties according to these traits. Each variety received a rating for each trait, after a discussion among the group to agree on the score. The positive traits in all varieties with highest scores were listed, and these again were pairwise prioritized. This pairwise prioritization resulted in a priority matrix. Drought tolerance was the most important in all pairwise comparisons (five counts in the matrix) and hence ranked first. Earliness was four times most important (all pairwise comparisons, except the case of comparison with drought tolerance) and ranked second. Grain size, storage suitability and stalk strength followed. Grain color was the least important.

Table 2. Results of Focused Group Discussions (FGDs) on preferred finger millet traits under HOPE project finger millet production zones of Simgida/Iramba, Rombo and Sumbawanga, Tanzania

Traits	Early maturity	High yielding	Good fermentation	Striga resistance	Blast resistance	Large panicles	Compact heads	Drought tolerance	Good taste	Good color	Points	Rank
Early maturity		High yielding	Early maturity	Early maturity	Early maturity	Large panicles	Early maturity	Early maturity	Early maturity	Early maturity	7	3
High yielding			High yielding	High yielding	High yielding	High yielding	High yielding	Drought tolerance	High yielding	High yielding	8	1
Good fermentation				Good fermentation	Good fermentation	Large panicles	Compact heads	Drought tolerance	Good taste	Good color	2	8
Striga resistance					Blast resistance	Large panicles	Compact heads	Drought tolerance	Good taste	Good color	0	10
Blast resistance						Large panicles	Compact heads	Drought tolerance	Good taste	Blast resistance	2	9
Large panicles							Large panicles	Drought tolerance	Good color	Large panicles	6	4
Compact heads								Drought tolerance	Good taste	Good color	3	7
Drought tolerance									Good taste	Drought tolerance	8	1
Good taste										Good taste	6	4
Good color											4	6

Ranking of varieties

Ranking in group discussion leaves the initiative with the farmers, thereby keeping them involved and in charge of selection process and selection of the product. During field days farmers were divided by gender into three categories of Women, Men and a mixture of Women and Men in Singida and two groups of Men and Women in Iramba. Each group consisted of 10-15 farmers. In Singida, females ranked P224 as their first choice with 54 points, followed by U15 with 51 points, KNE 688 with 48 points, UFM 149 with 46 points and Acc 32 and Acc 14 with 45 points (Table 3). KNE 628 did not fair well with the females and was ranked lowest together with the local. The males ranked U15 as the best followed by P224, Acc 14 and Acc 32, KNE 628 and KNE 688 (Table 4). Farmer's local variety was rated the least favored. Ranking by a mixture of females and males group placed P224 and U15 as the best with 53 and 52 points, respectively, followed by KNE 688 (48 points), Acc 14 (47 points) and Acc 32 (46 points). Closely following these were KNE 814 and UFM 149 while KNE 628 was placed last among the tested improved varieties, and the check last.

The different groups did rank the varieties differently but the ranks were relatively the same. The released varieties fared well in both groups, with the candidate varieties coming next and the local check being rated poorly. The local check overall was ranked low but performed highly on grain quality related traits like grain color, porridge and beer quality where it scored 5, and grain size where it scored 4. The released and improved varieties scored well in drought tolerance, early maturity, plant height (medium) and grain yield. All varieties except U15 and P224 fared poorly At maturity (Physiological Maturity) and at Harvest; which are the two most important stages for farmer acceptance of the variety. At Physiological Maturity the farmer is able to estimate the yield potential of the variety and appreciate the general plant aspect, while At Harvest evaluation gives the farmer an idea on ease of harvesting, the harvest losses like shattering, the effect of bird damage and how long the crop can stay in the field before lodging and starting to sprout. Borcke *et al.* (2010) working with farmers in Burkina Faso on sorghum observed that farmers define the performance of a plant in relation to the environmental conditions and in a more global way than breeders who have a rather additive vision of traits to enhance. They judge the productivity of a variety by integrating grain properties and ensuring high flour yield and quality, which enables them to predict how it may perform under a specific condition. Farmers look at the "plant type" and not at the individual trait and its ability to complete its growing cycle and secure the production under the local environmental conditions. Farmers thus tend to assess the total value of the variety as they inextricably linked; and all of these individual criteria must be met before they will accept a new variety.

Another trait where the released varieities-U15 and P224 excelled among all the gender in the two districts was threshability (Tables 3-5), the measure of ratio of the final grain obtained from the total panicle harvest and is usually associated with ease of threshing, one of the tedious practice in finger millet production. It is a trait valued by most women, the main gender involved in post-harvest handling and usually a main determinate for finger millet variety acceptance. Other improved varieties did well while the farmer local variety did poorly.

Varieties U15 and P224 are the first and only released finger millet varieties in Tanzania. Released in the year 2011 they are part of the regional germplasm program where different countries in the region contribute their elite materials, which are collated by ICRISAT and sent back to the programs for evaluation. Varieties U15 and P224 have already been released in Uganda and Kenya. The materials were earlier tested in the two districts for two seasons in 2010 and 2011 under PVS with the farmers to generate data for release. Through PVS and the harmonized East African variety release system it was possible to release the varieties after three years. The PVS process significantly shortened the period from the conventional average of seven years required to release a variety. Moreover farmers now associate with the varieties as their own and have adopted them very fast as there has been a farmer to farmer seed distribution and a number of farmers have acquired seed through field days. Witcombe and Joshi (1996) also noted a fast spread of seed from farmer-to-farmer through the local seed system, guaranteeing good adoption when using PVS.

Varieties U15 and P224 were included in the PVS for promotion purposes, while Acc 32, KNE 628, KNE 814 and KNE 688 are the new varieties tested to be included in the National Performance Trial (NPT). UFM 149 is a variety selected by the National Finger millet breeding program at Uyole, a high rainfall agro ecology mandate station, in Northern Tanzania. Under high rainfall conditions the variety is high yielding with yield of up to 4 t/ ha in farmers' fields, but does not do well under low rainfall areas like Northern and Central Tanzania. Farmers in Singida, especially female farmers, have developed the practice of planting finger millet seed in nurseries and transplanting just at the onset of the rainy season and are now able to grow varieties with longer maturity periods. Farmers in these areas have specifically liked UFM 149 as it tends to yield higher and produce big heads, when transplanted and that explains why UFM 149 is ranked by women farmers in Singida as number 4 compared to the male counterparts who ranked it as number 8. The variety could even have attained a higher rating if not for the reason that the grains are light colored which is not a preferred trait in the area. The UFM 149 is already at NPT for release in the southern highlands, but it is also targeted for the female farmers in Singida who transplant finger millet. The difference in preference for UFM 149 shows that when introducing varieties for PVS evaluation, farmer practices should also be taken into account. It also shows that at times it might be necessary to do target introductions and releases of varieties for specific areas and farming practices.

In Iramba female farmers ranked U15 first followed by P224 with 56 and 55 points, respectively. These were ranked as very good in almost all the traits evaluated. KNE 688 followed with 53 points, KNE 814 and Acc 32 with 52 point each, UFM 149 came in 6th with 49 points, followed by KNE 628 and the farmer local and Acc 32 coming last. The Men had about the same ranking with U15 and P224 coming first followed by KNE 688, KNE 814,UFM 149, Acc 14 and Acc 32, which was again ranked last together with the farmer local. Both gender ranked U15 and P224 very highly in almost all the traits. Most of the improved varieties were ranked high in drought tolerance, early maturity and plant height (medium). Men and women groups rated all varieties except U15 and P224 low at maturity (Physiological maturity) and at harvest evaluation. Breeders need to focus more on these traits. The improved varieties fared poorly mainly as a result of low assessment in the grain quality especially grain color (brown always preferred for Ugali (stiff porridge), porridge and local beer quality). There is therefore a need for breeders to test their future varieties early in the breeding cycle for quality traits to make sure appropriate varieities eventually reach the farmers. The same has been observed in PVS trials in Kenya and Uganda.

It is apparent that many varieties are desired and maintained for other reasons than yield and yield-related characteristics. One of the main features of traditional varieties, in comparison with modern varieties, is their better compatibility with local farming systems and socio-economic structures, which is reflected in specific characteristics like good taste, preferred grain color and size, head size and compact head shape. Important as yield may be for food production, other characteristics may additionally determine overall suitability. This overall suitability will be determined by a certain balance of a number of important characteristics. Modern cultivars are abandoned more for grain yielding ability and lodging susceptibility, while traditional cultivars are often abandoned for drought susceptibility and quality, where they are expected to excel.

Table 3: Criteria score of eight (8) test varieties and a local check evaluated by female farmers in Singida during the 2013-14 season

Variety	Drought tolerance	Early maturity	Plant height	Grain size	Grain color	Grain yield	Thresh ability	Ugali quality	Porridge quality	Beer quality	Rank at maturity	Rank at Harvest	Total	Rank
ACC# 14	4	5	4	4	4	4	4	3	4	4	3	3	**45**	**5**
ACC# 32	4	4	4	4	4	4	4	3	4	4	4	3	**45**	**5**
KNE 628	4	4	4	4	4	3	4	3	4	4	3	3	**42**	**8**
KNE 688	4	5	4	4	4	4	4	3	5	4	3	4	**48**	3
KNE 814	4	4	4	4	4	3	4	3	4	4	3	3	**44**	7
Local check	3	3	4	4	5	4	3	3	5	5	2	2	**42**	8
P 224	5	5	5	5	5	4	4	3	5	5	4	5	**54**	1
U 15	5	5	5	4	5	4	5	3	4	4	4	4	**51**	2
UFM 149	4	4	4	4	3	3	4	3	5	4	3	3	**46**	4
Mean	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**3**	**3**	**46**	

Table 4: Criteria score of eight (8) test varieties and a local check evaluated by male farmers in Singida during the 2013-14 season

Variety	Drought tolerance	Early maturity	Plant height	Grain size	Grain colour	Grain yield	Thresh ability	Ugali quality	Porridge quality	Beer quality	Rank at maturity	Rank at Harvest	Total	Rank
ACC# 14	4	4	5	4	4	4	4	4	4	4	3	4	48	3
ACC# 32	4	4	4	4	4	4	4	3	5	5	3	3	**47**	4
KNE 628	4	4	4	4	4	3	4	4	5	4	3	4	**46**	7
KNE 688	4	3	4	4	4	5	4	3	5	5	4	4	**47**	4
KNE 814	4	4	4	4	4	4	3	4	5	4	3	4	**47**	4
Local check	3	3	3	4	5	3	3	3	5	5	3	3	**42**	9
P 224	4	4	5	4	4	4	4	3	5	5	5	4	**52**	2
U 15	5	4	5	3	5	5	5	4	5	5	4	4	**53**	1
UFM 149	4	3	4	4	4	3	4	3	5	5	3	3	**45**	8
Mean	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**5**	**5**	**3**	**3**	**47**	

Table 5: Criteria score of eight (8) test varieties and a local check evaluated by both sex farmers in Singida during the 2013-14 season

Variety	Drought tolerance	Early maturity	Plant height	Grain size	Grain colour	Grain yield	Thresh ability	Ugali quality	Porridge quality	Beer quality	Rank at maturity	Rank at Harvest	Total	Rank
ACC# 14	4	5	4	4	4	4	4	3	4	4	3	3	**47**	4
ACC# 32	4	4	4	4	4	4	4	3	5	4	3	3	**46**	5
KNE 628	4	4	4	4	4	3	4	3	4	4	3	3	**44**	8
KNE 688	4	4	4	4	4	4	4	3	5	5	4	4	**48**	3
KNE 814	4	4	4	4	4	3	4	3	4	4	3	4	**45**	6
Local check	3	3	4	4	5	3	3	3	5	5	2	3	**42**	9
P 224	5	4	5	5	5	4	4	3	5	5	5	4	**53**	1
U 15	5	4	5	4	5	4	5	4	5	4	4	4	**52**	2
UFM 149	4	3	4	4	4	3	4	3	5	5	3	3	**45**	6
Mean	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**5**	**4**	**3**	**3**	**46**	

Table 6: Criteria score of eight (8) test varieties and a local check evaluated by female farmers in Iramba during the 2013-14 season

Variety	Drought tolerance	Early maturity	Plant height	Grain size	Grain colour	Grain yield	Thresh ability	Ugali quality	Porridge quality	Beer quality	At Maturity	After Harvest	Total	Ranking
ACC# 14	5	5	5	5	4	4	4	5	4	4	4	4	**52**	4
ACC# 32	3	5	5	4	5	4	4	4	5	5	1	1	**45**	9
KNE 628	4	4	4	3	4	4	5	5	4	4	2	3	**46**	7
KNE 688	5	5	4	5	5	5	5	4	4	4	4	3	**53**	3
KNE 814	5	5	5	5	5	4	5	4	5	5	3	2	**52**	4
Local check	4	4	4	4	5	4	4	4	5	5	3	2	**46**	7
P 224	5	5	5	5	4	5	5	5	4	4	4	4	**55**	2
U 15	5	5	5	5	5	4	5	4	5	5	5	4	**56**	1
UFM 149	3	3	5	5	4	5	5	5	3	3	3	4	**49**	6
Mean	**4**	**4**	**4**	**5**	**4**	**4**	**5**	**4**	**4**	**4**	**3**	**3**	**50**	

Table 7: Criteria score of eight (8) test varieties and a local check evaluated by male farmers in Iramba during the 2013-14 season

Variety	Drought tolerance	Early maturity	Plant height	Grain size	Grain colour	Grain yield	Thresh ability	Ugali quality	Porridge quality	Beer quality	At Maturity	After Harvest	Total	Ranking
ACC# 14	5	5	5	5	4	4	4	5	4	4	3	3	**50**	6
ACC# 32	4	4	5	4	4	4	4	4	5	5	1	1	**46**	8
KNE 628	4	4	4	4	4	5	5	5	4	4	2	3	**48**	7
KNE 688	5	4	4	5	5	5	5	5	5	5	4	3	**53**	3
KNE 814	4	5	5	5	5	5	4	4	5	5	4	3	**53**	3
Local check	4	4	4	4	4	4	4	4	5	5	3	2	**46**	8
P 224	5	5	5	5	5	4	5	5	4	4	4	5	**54**	2
U 15	5	5	5	5	5	4	5	4	5	5	4	4	**55**	1
UFM 149	4	3	5	5	5	5	5	5	4	4	3	4	**51**	5
Mean	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**4**	**3**	**3**	**50**	

Quantitative and Quantitate data

In the course of the trials, scientists and extension staff recorded quantitative and qualitative data in the PVS plots. Data collected included Days to 50% Flowering (days), plant height (cm), agronomic aspect (score 1-5) and grain yield (t/ha) data. Data analysis was done using Genstat v15 where farmers were treated as replicates, and gender and district as treatments.

In Singida average Days to 50% Flowering (DAF) ranged from 67 days in Acc 14 and P224 to 89 days in the farmer local (Table 8). Plant height ranged from 65 cm in UFM 149 to 84 cm in P 224 compared to 87 cm in the farmer local, with an average of 79 cm. These heights were preferred by the farmers as it makes harvesting easier and plants less prone to lodging. U15 had the best plant aspect score of 1.5 with all the test varieties being rated good and the local check average (Score 3). Performance of the varieties in the 15 farmer fields revealed P224 to be the best yielder with 2.77 t/ha followed by KNE 688 (2.68 t/ha), UFM 149 (2.60 t/ha), Acc 32 (2.57 t/ha) and the farmer local (2.40 t/ha) with an overall mean of 2.35 t/ha. KNE 628, Acc 14 and U15 did not perform well yielding lower than the local check (Table 8).

In Singida all the varieties were significantly shorter than the local (Table 8), the shortest being UFM 149 (65 cm), followed by U15 (74 cm) and KNE 814 and Acc 14 both with 76 cm. Short height is usually associated with early maturity, thus drought escape, and lodging resistance, which is a very favorable trait in finger millet. Although UFM 149 is the shortest (65 cm), it is a long duration variety. This is because UFM 149 is a spreading variety, yet height is taken as vertical distance from the ground to the tip of the plant. Grain yield ranged from 1.64 t/ha in KNE 628 to 2.77 t/ha in P224. The favorite variety U15 did not fair well, with a yield of 2.00 t/ha, falling below the average yield of 2.35 t/ha. The farmer local yielded fairly well, 2.4 t/ha despite being rated lowly by the farmers. This confirms what has always been stated that farmers in dry land areas do not select varieties for only their grain yield but for other factors, especially those that assure them a harvest. The varieties intended for NPT Acc 32, KNE 814, UFM 149 fared well in terms of yield, with yields above average.

In Iramba DAF ranged from 69 in U15 to 90 days in KNE 628 and UFM 149. Varieties U15, P224, Acc 32 and KNE 688 had significantly lower DAF than the check while KNE 628 and UFM 149 had significantly longer days to maturing than the farmer local. The difference in DAFs data from the two districts shows the effect of environment on variety performance and emphasizes the need to test varieties in specific areas before release. Again all the varieties were shorter than the farmer local. Yield ranged from 1.99 t/ha in U15 to 3.73 t/ha in UFM 149. Varieties Acc 32, P224, KNE 814, KNE 688, UFM 149 performed better than the farmer local. Candidate varieties for release KNE 814, KNE 688 and UFM 149 performed better than the released varieties (U15 and P224). The significance of farmers going for the variety not only for yield is more emphasized in Iramba. Although U15 was the least yielding variety in the trials, it was ranked number one by the farmers using other criteria other than yield. Currently it is produced by more farmers compared to all other high yielding varieties. It is also important to note that the 2.0 t/ha yield achieved by U15 is good yield in finger millet so farmers are comfortable with it; it appears low on the list because U15 has been tested against high yielding varieties. The candidate varieties yielding more than the recently released varieties shows the availability of high potential varieties in the pipeline ready to be tested in farmers' fields for acceptance.

Overall the released variety U15 had the shortest days to flowering (69) and recorded the shortest height (84.2 cm), while all the tested varieties matured early and had shorter maturity duration than the farmer variety.

Table 8: Means of the agronomic and yield traits taken on the eight test varieties and the farmer local evaluated in Singida and Iramba districts during the 2013-14 season

Variety	Days to 50% flowering[1]	Plant height[2]	Agronomic score [3]	Yield ($t\ ha^{-1}$)[4]
Singida				
ACC#14	67	76	2.3	1.99
ACC#32	71	80	2.2	2.57
KNE 628	71	79	2.2	1.64
KNE 688	73	82	2.1	2.68
KNE 814	71	76	2.0	2.28
Local check	89	87	3.0	2.40
P224	67	84	2.1	2.77
U15	68	74	1.5	2.00
UFM 149	71	65	2.0	2.60
Mean	**73**	**79**	**2.2**	**2.35**
StdD	**5.3**	**1.9**	**-**	**0.25**
Iramba				
ACC# 14	77	45	1.0	2.30
ACC# 32	72	46	2.3	2.69
KNE 628	90	47	1.0	2.54
KNE 688	72	54	1.0	3.38
KNE 814	76	49	1.0	2.83
Local check	80	61	1.5	2.65
P 224	70	48	1.0	2.81
U 15	69	43	1.0	1.99
UFM 149	90	50	1.0	3.73
Mean	**78**	**50**	**1.2**	**2.77**
StdD	**4.7**	**4.4**	**-**	**0.24**
Grand Mean	**78**	**64**	**1.7**	**2.57**

[1]Days 50% flowering, assessed on plot basis; [2]Vertical distance in cm from the base of the plant to the tip; [3]General appearance of the crop on plot basis assessed on a scale of 1-5, 1=very good, 2=good, 3=average, 4=poor, 5=very poor; [4]Grain Yield in tons per hectare

Early maturity and short height are the most preferred traits in finger millet as the former helps the crop escape drought and the latter is associated with resistance to lodging. This explains why U15 was the farmers' favorite despite being the least yielding (2.05 t /ha) among the tested varieties.

Analysis of Variance (ANOVA) with Farmer as replications and gender of the farmer hosting the trial forming a sub-treatment showed Variety and Farmer in each district to be highly significant for all the traits analyzed while gender was significant for only yield. This called for combined analysis, where District formed the blocks. Combined analysis of Variance revealed Variety, Farmer, District and the Variety*Farmer interaction to be highly significant (P<0.001) for all the traits with District explaining most of the variation in traits (Table 9). The high variation in the Districts shows differences attributed to mainly rainfall, soil fertility and farming practices. Highly significant difference among varieties show the high diversity available in the finger millet varieties and an opportunity for farmers to choose from. Significance of the Farmer is a result of the difference in agronomic practices which lead to the varieties performing differently among farmer fields, hence a need to train farmers more on the Good Management Practices (GAP) to improve crop productivity and to narrow the gap in performance among the farmers and between farmers and on station fields. The interaction between farmer and cultivar shows that the varieties perform relatively different among the farmers' fields necessitating establishing PVS trials in different areas and agro ecologies to capture the varieties best suited for specific areas even in the same agro ecology.

Gender was only significant for yield (P<0.001) with varieties performing relatively lower in female managed fields (average yield 2.36 t/ ha) compared to the male managed fields (average 2.43 t/ha). Even in the traits which were not significant for Gender; varieties were taller in the male managed fields (average 64.8 cm) compared to the female managed fields with 58.7 cm where they matured faster in the female managed (sign of stress) compared to the male managed fields. These differences are not as a result of better management on the male counterparts but rather due to uneven distribution of resources. During the group discussion, it was disclosed that in a household men always are the first to choose the piece of land to plant, they always plant first and other cultural practices like weeding and harvesting are first done on a man's plot. These give them the edge to have more fertile plots and to plant earlier to take advantage of the unreliable rains. It also explains why females opt more for risk averting traits during selection. The biplot of PC1 and PC2 yield scores was done to provide visual inspection and interpretation of genotype by environment (G x E) components and group genotypes based

Table 8: ANOVA table for different traits in finger millet taken on 31 farmers' fields in Central Tanzania, during 2013-14 season

Source		Mean Squares		
of variation	Df[1]	Plant height[2] (cm)	DAF[3]	Grain yield[4] (tha^{-1})
District	1	58070.1***[5]	1262.7***	12.6***
Variety	8	1075.2***	1198.9***	4.88***
Farmer	30	1780.6	540.8	5.24***
Gender	1	0.04ns	1.4ns	5.05***
Variety * Farmer	216	59.6*	59.5ns	0.49**
Error	28	30.42	92.6	0.22
Total	284	471.1	149.7	1.15
CV[6]		8.6	12.7	18.3

[1]Degrees of freedom; [2]Vertical distance in cm from the base of the plant to the tip; [3]Days to 50% flowering; [4]Grain yield in tons per hectare. [5]Degree of significance, *=> 0.05, *=> 0.01, *=> 0.001; [6]Coefficient of Variation.

on similarities of performance across diverse environments (Thillainathan and Fernandez, 2001). The biplot shows that the most adapted varieties for the two districts are KNE 814 and KNE 688 due to their location along the vertical axis and yields above average (Fig.1). The most stable genotypes are Acc 14, KNE 814 and KNE 688. Variety UFM 149 is a high yielder specifically suited for Iramba and Acc 32 and P224 are specifically suited for Singida. Before any variety is released it has to be stable across seasons and locations in a DUS (distinct, uniformity and stability test) hence it identifies KNE 688 and KNE 814 as good candidates for release in the central zone of Tanzania.The results show that U15, one of the released and favorite variety among farmers, performed less than the test varieties, indicating availability of more promising new varieties.

CONCLUSION

The farmers' methods for defining traits turned out to be more multivariate than the breeders' formal understanding of these same traits. This was especially so for the criteria of grain quality, earliness, and productivity for which the farmers' definition encompasses factors such panicle size and shape, grain flour yield, cooking and brewing quality for traditional beers. However, rating results across farmer groups were variable. A disagreement between female and male ratings was especially found for the grain quality traits where women tended to be more informed and detailed, as previously reported by Brocke *et al.* (2010).

Full participation of farmers was the key tool for evaluation and adoption of improved varieties. Famers identified their selection criteria of improved varieties which they accordingly listed as follows: yield related traits (effective number of tillers, number of fingers per ear, plant height, finger length, stand and uniformity at maturity, days to maturity and biomass yield), seed color and blast disease reaction.

The farmers selected varieties and grain yield were highly correlated, Farmers participation was therefore very important in variety evaluation and selection. Based on agronomic traits and farmers' visual observation at field, varieties P224 and U15 were selected for continued cultivation. If yield is taken as the only selection criterion, P224, KNE 688, UFM 149 should have been selected for Singida and UFM 149, KNE 688, KNE 814 and P224 would have been selected for Iramba. It also proved crucial that truly representative community representation is essential suggesting that participatory selection has to be coupled early on with decentralized seed

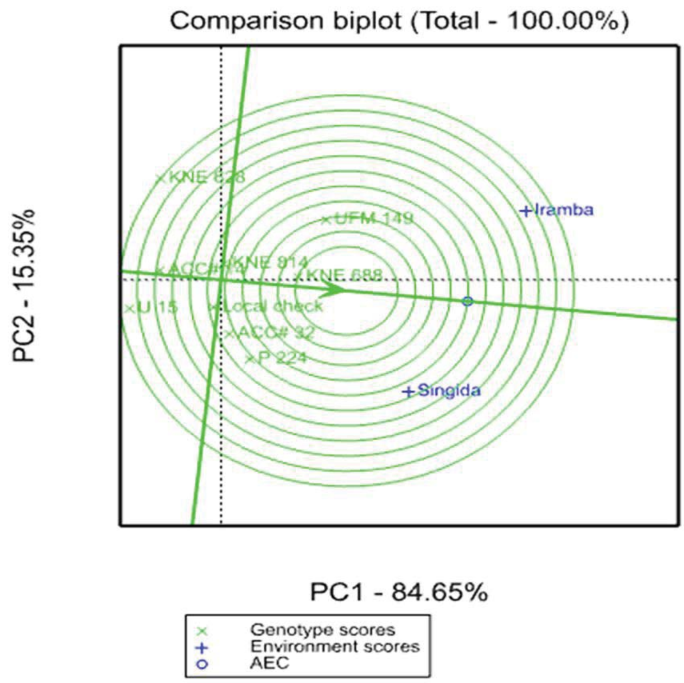

Figure 1: Biplots of eight improved finger millet varieties and a farmer local evaluated in 31 farmer fields in Singida and Iramba districts of Central Tanzania in 2013-14.

multiplication programs. Scaling up of a participatory selection program implies that formal sector research must collaborate with organized groups of farmers, rather than individuals, to share costs and responsibilities.

Using participatory approach, there was high rate of adoption of varieties identified and a significant reduction in the number of years that are required in the varietal identification and adoption. In crops like coarse cereals, especially finger millet, sorghum, pearl millet and minor millets, where infrastructure for research is lacking, an elaborate participatory approach would be more rewarding. It took three years (2009-2011) to test and release the two varieties (U15 and P224) and another three years for these varieties to be widely adapted in Central and Northern Tanzania.

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STATEMENT OF NO CONFLICT OF INTEREST

We the authors of this paper hereby declare that there are no competing interests in this publication.

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