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Effectiveness of Participatory Breeding and Variety Selection for Sorghum Technology Adoption: Milenge District

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Abstract

Participatory breeding and variety selection has been proposed as an effective way of disseminating improved technologies to farmers for social-economic benefits [1]. As a result the Sorghum and Millets Improvement Programme (SMIP), of the Zambia Agriculture Research Institution (ZARI), in collaboration with the farming systems scientists at Mansa Research Station, in Luapula Province tested the effectiveness of this methodology. The effectiveness of this method was evaluated based on the number of farmers rating new improved agriculture technologies favourably and willing to adopt the improved technologies after being exposed to participatory breeding.

An on-farm participatory sorghum variety demonstration trial was conducted during the 2011/2012 rainy season in Zambia, Milenge district, of the Luapula province. The trial had consisted of 12 improved sorghum germplasm lines of which six were hybrids and six were varieties developed by SMIP. The germplasm was evaluated by the farmers, extension and research staff on farm. The germplasm was evaluated for it value for cultivation and use. The methodology that was used is called participatory breeding which is part of the broader concept of participatory rural extension and the Innovative Platform for Technology Adoption (IPTA) advocated by the Forum for Agriculture Research in Africa (FARA), FARA, 2012.

The results of the methodology indicated that this methodology is effective if farmers are committed and good agriculture policies are in place. When farmers feel part of the developmental process, it is easier for them to adopt improved technologies.

Keywords: *Sorghum; Grain yield; Threshing ratio; Plant vigour*

Introduction

The rural economy of Zambia is dependent on agriculture. Milenge district, like most of the rural districts in Zambia, is dependent on agriculture. Sorghum is one of the five major crops grown in the district that includes maize, cassava, sweet potatoes and beans. Sorghum is one of the essential sources of income in the district grown by almost 80% of the population. The Sorghum farming system plays an important role in the economy of Milenge district. The role that sorghum plays in this economy can be enhanced if strategies pursued to increase sorghum production and earnings from sorghum for farming households are enhanced [2].

Sorghum in is one of the primary staple foods as well as an essential cash crop for small-holders. Since the Agricultural sector in Milenge district is one of the keys to development and a major factor in poverty reduction, there was a need to investigate, gather and analyse the various relevant agronomic and socio-economic factors that influence the adoption of improved sorghum technologies using participatory breeding and variety selection.

Farmers in Milenge district grow sorghums landraces that are late maturing using the transplanting method. This method is usually labour intensive. However, this may not necessarily be a bad thing because the late maturing varieties also have a role to play in food security. Local sorghum varieties are low yielding (0.3 to 0.55 tons/ha) according to Hamukwala., *et al*. [3], 0.67 tones according to CSO, 2010 and 0.844 tones according to IAPRI, 2013. In addition, IAPRI reported that in 2011/2012 season only 0.68% of rural farmers in Luapula province grew sorghum while the national average was only 2.74%.

Sorghum local landraces take about six months to mature as compared to three months for the improved varieties. The improved sorghum varieties developed by the sorghum breeding programme can yield up to 8tonnes per hector [4] and even more for sorghum hybrids. However most small scale farmers are unable to produce this much. In unpublished reports by SMIP farmers can produce about 1.4 tons of sorghum per hector under poor management with no fertilizer using the improved varieties as a result there is now a paradigm shift to produce low input technologies for small-scale farmers.

As early as 1990 improved sorghum varieties were introduced in Milenge, but unfortunately they were not adopted by farmers [5]. Information on the actual factors that lead to the low adoption of the improved sorghum varieties is not very clear. However one of the reasons cited for the low adoption of varieties by farmers is the linear approach to technology dissemination [6]. Another reason is that a great deal of farmers shun away from growing sorghum because of birds, which are a major pest in white grain sorghums [7]. Therefore there was a need to assess the performance and acceptability of these technologies by the farmers in Milenge district using participatory breeding and variety selection.

The overall objective of this social-economic research was to investigate the agronomic and socio-economic factors affecting the adoption of sorghum improved varieties in Milenge district. The Specific objectives of this research were: (i) To evaluate the performance of the improved sorghum varieties and (ii) To evaluate the acceptability of improved sorghum varieties among farmers in Milenge (iii) Assess the performance new variety against bird pests.

The significance of this study is that despite all the research efforts by SMIP, since the inception of ZARI in 1953, the technology adoption rates have been very low [5,8]. Some of these reasons are not entirely due to the technology dissemination methods but also the way these technologies were disseminated and the somewhat negative social perception of sorghum as a food crop [9].

Participatory breeding and variety selection is part of a broader extension methodology called the Innovative Platform for Technology Adoption (IPTA), which has been encouraged by the Forum for Agriculture Research in Africa (FARA), as a useful tool for agriculture development. The IPTA concept is a non-linear model for technology development and adoption. It is a holistic model for technology development, dissemination and adoption. This methodology was tried to see its effectiveness in rural agriculture development.

Materials and methods

The experimental design that was used for the experimental trials was the Randomized Complete Block Design (RCBD) with four replication. Twelve improved sorghum germplasm lines were used in the trial. The first set of twelve sorghum entries was planted in an area called Kasepa. This was given to a women's local organization called "Tukosele Women Group". This was to ensure local participation and ownership of the technology adoption process. This trial had two replications. The second set of twelve sorghum entries was planted in two sites namely Kapalala and Sokontwe. The first replication was planted in Kapalala camp and the other replication was planted in Sokontwe camp.

Farmers were organized in groups. Discussions were held with farmers in which the objectives and monitoring indicators were discussed. The list of important factors that were observed and considered important by the farmers included (i) Plant vigour (ii) Pest resistance (iii) Bird damage (iv) Plant height (v) Threshing ratio (vi) Grain yield (vii) Grain colour (viii) Storage pests (ix) Milling ability and (x) Taste.

Analysis of variance was used for variables such as yield, bird damage and threshing ratio. Differences within and between the means were tested using Duncan's Multiple Range Test. Three quantitative variables grain yield (Kg/ha), bird damage (%) and Threshing ratio (%) were analyzed using Analysis of Variance (ANOVA) from the Statistical Package for the Social Sciences (SPSS), version 14.

To analyse farmers' visual assessment using scores, frequencies were used to profile their perception of the performance of the improved varieties. Pearson correlation was used for continuous variables. According to Vijay G. [10], "if even one of the variables is ordinal (ranked categorical) or non-normal, the "Pearson" method cannot be used. Instead "non-parametric" methods must be used.

Results

Yield performance Kgs/ha

The standard for comparing sorghum yield per hector under farmer conditions is 1 ton per hector. This is because the average yield of sorghum under farmer conditions in 2010 was reported as 1 ton per hector [11]. Based on this information, any improved variety or hybrid giving less than 1.5 tones is considered to be a poor performer in terms of grain yield.

Variety	Yield kgs/ha
ELT1-16	833[a]
(FRAM x SDS3843) F6-5	1333[a]
SDS876-342 (OT) 8-2-1	1500[ab]
90CC655-1073-3	1667[ab]
ZSV-15	1833[ab]
ZSV-36R	3667[cb]
WP-13	3667[cb]
Kuyuma	4333[c]
ZSV-12	4500[c]
Sima	4667[c]
(ICSV112 x WSV187)15-1-1-1	5000[c]
(ICSV112 x SDS3136) 1-13-1	5833[c]

Table 1: *Yield performance under farmer conditions.*
Ratios connected by the same letter are not significantly different at alpha = 0.05.

Bird Damage

Bird damage was calculated as a percentage of the total number of plants attacked by birds. Farmers assessed sorghum for bird damage by counting all sorghum plants that were attacked by birds and the total number of plants in a plot. Bird damage percentage was calculated as the number of plants attacked by birds divided by the number of sorghum plants in a plot area, multiplied by 100. The higher the number the higher the bird damage.

Rating	Damage %	Damage Description
1	< 20%	No bird damage
2	21-40%	slight bird damage
3	41-60%	moderate bird damage
4	61-80%	severe bird damage
5	> 80%	very severe bird damage

Table 2: *Bird damage farmer rating scale.*

Variety	Bird Incidence %
ELT1-16	1.0[a]
(FRAM x SDS3843) F6-5	2.0[ab]
SDS876-342 (OT) 8-2-1	18.4[abc]
90CC655-1073-3	27.8[abcd]
ZSV-15	34.2[abcd]
ZSV-36R	50.6[abcd]
WP-13	52.9[abcd]
Kuyuma	54.1[bcd]
ZSV-12	58.8[cd]
Sima	58.9[cd]
(ICSV112 x WSV187) 15-1-1-1	59.8[cd]
(ICSV112 x SDS3136) 1-13-1	80.7[d]

Table 3: *Bird incidence as a percentage.*

Ratios connected by the same letter are not significantly different at alpha = 0.05.

Threshing ratio

Threshing ratio was calculated as grain weight divided by the head weight and multiplied by 100. The higher the ratio percentage, the more the grain that is recovered from the sorghum panicle. High ratios imply that more grain is recovered per panicle and hence post-harvest losses are minimized.

Variety	Threshing Ratio (%)
ELT1-16	27.1[a]
(FRAM x SDS3843) F6-5	42.7[ab]
SDS876-342 (OT) 8-2-1	44.7[ab]
90CC655-1073-3	52.1[bc]
ZSV-15	55.0[bcd]
ZSV-36R	62.6[bcde]
WP-13	71.4[cde]
Kuyuma	73.2[cde]
ZSV-12	73.3[cde]
Sima	76.0[cde]
(ICSV112 x WSV187) 15-1-1-1	79.6[de]
(ICSV112 x SDS3136) 1-13-1	81.0[e]

Table 4: *Threshing ratio reported as a percentage.*

Ratios connected by the same letter are not significantly different at alpha = 0.05.

Grain yield vs threshing ratio

Grain yield and threshing ratio were highly correlated with a correlation coefficient of 0.96and confidence interval of 0.84 to 0.99. The threshing ratio is a good indicator of yield and vice versa. If the threshing ratio is high the chances of recovering more grain is also high.

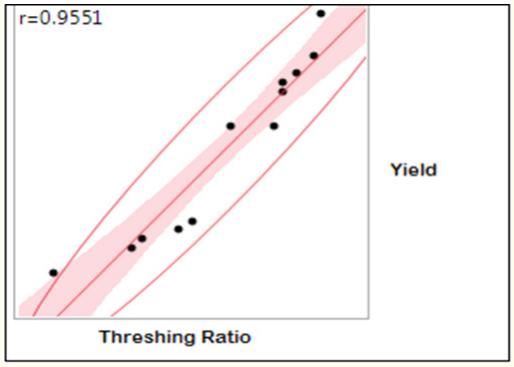

Figure 1: *Yield vs threshing ratio.*

Plant vigour

The frequency of farmers rating seedling vigour of improved varieties compared to local varieties is shown in the pie-chart below. Of the 100 farmers interviewed, 79% of rated the vigour as very good and only 4% rated the vigour as moderate.

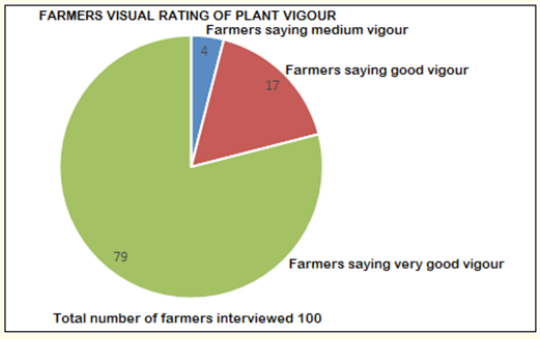

Figure 2: *Plant vigour.*

Plant height

Plant height is an important trait for farmers because it affects how well they will harvest the crop. Plant height has implications on labour intensiveness. Farmers claim that sorghums that are about 1.5 meters tall are easier to harvest and so this was an important factor to consider. Very short or very tall sorghums are considered undesirable at the time of harvest. According to the farmers very short sorghums posed a problem at harvesting due to constant bending which leads to backaches if the fields are large. Furthermore, other farmers claim that it is easier to do bird scaring in a field of sorghums that are shorter because they can easily see where birds are in the field. This makes perfect sense because tall sorghums will normally obscure the visibility of the field. On the other hand very tall sorghums take twice as much time to harvest because farmers have to cut the sorghum stem at two points to get to the panicle or they have to bend the sorghum plants to cut the panicle. A consensus rating of height by farmers is shown in table 5.

Rating	Height in (cm)	Height Description
1	< 100 cm	Too short
2	101-150	Short
3	151-200 cm	Medium
4	201-250 cm	Tall
5	> 250 cm	Very tall

Table 5: *Plant height farmer rating scale.*

The results in figure 3 show that plant height of improved sorghum ranged from short to tall. The improved varieties were neither too short nor very tall according to farmers. The pie-chart bellows shows the farmer preferences for plant height.

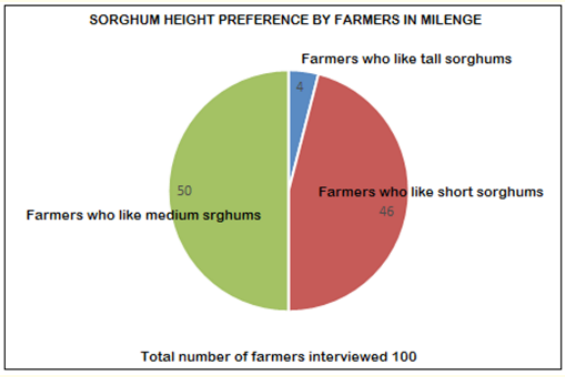

Figure 3: *Plant height farmer scores.*

Grain colour

For grain sorghum grown for food, the most preferred colour by households is white 66%, then brown 25% and red is the least preferred 9%. Upon discussion farmers admitted that grain colour is not an issue if sorghum is grown for sale. However for food purposes taste and texture were other attributes that needed further exploration. Due to the time limitation information on the shelf life of grain, milling quality and oganoleptic tests were not done but it is important to establish this information. The results for grain colour are as shown in figure 4.

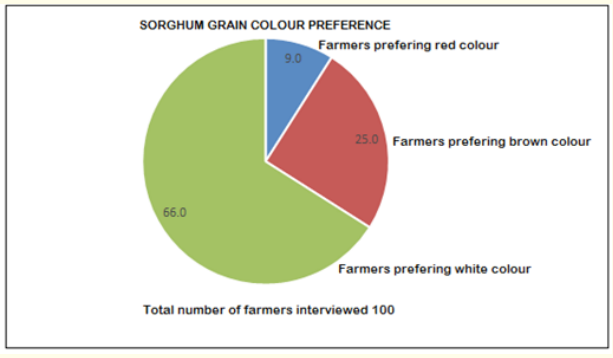

Figure 4: *Grain colour preferences.*

Conclusion

Generally the improved varieties performed well in terms of agronomic and social-ecomical acceptance by farmers. The social-economic and agronomic evaluation indicates that the improved varieties can do better in Milenge unlike the myths that farmers have that the improved varieties cannot do well. Some farmers in an area called Kasepa claimed that the improved sorghum that they planted the way they plant local sorghum did very well. This is an indication that the improved varieties could fit well in the farming system of Milenge

Of the two major reasons cited for low technology adoption, (i) linear technology dissemination and (ii) bird pest problems, one of them was nullified as a cause for low technology adoption. The low adoption of improved varieties in Milenge could not be attributed to susceptibility of improved sorghum varieties to birds. Much as the improved sorghum varieties are susceptible to birds so are the local landraces. Besides that, sorghum is not the only crop affected by birds; rice, wheat and sunflower are equally affected by birds. In very severe situations even maize is attacked by birds and other wild animals such as warthogs and monkeys.

Since the Sorghum Breeding Programme is very much aware that farmers are weary of farm inputs costs, pest problems such as birds and the market, the social economic-research included a new developed red sorghum variety called ZSV-36R, since this technology received sufficient merit by the farmers the programme recently released this low input variety in September 2013, through the Seed Certification and Control Institute of Zambia (SCCI), [12]. This variety is less susceptible to birds and has a market advantage because the industries are using it to make malt. So the farmers can switch to growing red sorghum and make an income. Farmers can then use the income to buy food. This is another form of food security.

Attitude and comittiment by the farmers plays an important role as was the case in areas where the birds completely destroy sorghum. In Kasepa the farmers showed comittiment and good attitude towards the improved varieties and good results were obtained. The lesson learned is that the use of the Innovative Platform for Technology Adoption works if there is commitment and importance attached to a crop. The Innovative Platform is a useful tool for bringing about rural agriculture development but the following issues need to be resolved if it is to work properly [13].

Government funding and policies-some policies need to be adjusted to prevent the exploitation of farmers by briefcase businessmen who buy grain at extremely low prices robbing the farmer of their profits. The Zambian bureau of standards could be more involved on the platform and ensure that farmers are given high quality inputs by agro-suppliers. Government could also prioritize funding to the agriculture sector. This could be brought about by creating awareness of the IPTA to facilitate buy in of decision makers. The funding system has to be reformed so that it can meet the demands of farmers at grass root level.

Information and communication-needs to be enhanced through consistent interactions among stakeholders and mainstreaming the IPTA in the day to day activities in all the institutions involved. Information sharing should be encouraged at all levels even though the cost of obtaining information is high. The short message sending (SMS) option on mobile phones should be explored more to foster easy access to information sharing. Mobile communication is emerging as a powerful tool in information and technology dissemination and media institutions should take advantage of this. However, community radio stations, Internet and information centers, farmer groups and cooperatives are still very important. The challenges to mobil communication are usually poor signals and network coverage [14].

Attitude change-was considered a very important social attribute in agriculture development. Many people advocated for a change in attitude. This was echoed at all levels from farmers, Extension Officers, Researchers and indeed all stakeholders in the way that they do things.

Value addition and markets-these two were pointed out as probably the most important drivers in sorghum production. Markets and value chains are very critical, without markets farmers are not willing to grow anymore than they can consume. This is because surplus will normally go to waste. Marketing and value chains are there for an important component of the IPTA Concept. More efforts need to be made to insure that all stake holders internalize the IPTA concept. The concept of the Innovative Platform needs to be widely disseminated.

Farming as a business- Small scale farmers must look at farming as a business from which they can make full returns. They should analyse gross margins and wisely select crops that have low production costs but high returns.

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