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Research Article

Large-Scale Demonstration of Improved Sorghum Technologies in Selected Areas of Assosa Zone, Benishangul Gumuz Region, Western Ethiopia

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Abstract

This study was conducted at Assosa and Bambasi district of Assosa zone. The district was selected purposively based on potential and accessibility for sorghum production: A total 603 (male 516, female 87) farmers were involving sorghum largescale demonstration production. 339 hectares of land were selected and identified for the activity; four quintal of improved sorghum assosa-1 variety distributed with 10 kg/ha seed rate and with 75 cm and 15 cm between row and plant all fertilizer application used based on recommendation 100 kg of NPS and 50 kg of UREA were used. All farmers contribute and prepare from 0.25 to 1 ha. of land for the activity. A total of 586 farmers, 31 development agents and 9 agricultural experts were participated on the training. About 1027 participants (700 M and 200 F, 40 M and 10 F experts, 75 M and 2 F higher official) were attend the field day. Mean grain yield of improved sorghum (Assosa-1) variety in Assosa and Bambasi districts was 27 qt/ha., and 30 qt/ha; respectively recorded. The total mean yield of improve sorghum Assosa-1 variety was 28.75 qt/ha. higher than the farmers practice 15 qt/ha. This difference is due to the utilization of best-fit of the variety in the areas and the application of the recommended agronomic practices and field management. From the total of 339 hectare of land 9430.5. quintal of yield was harvested.

Keywords

Large-scale Demonstration, Cluster, Extension, Improved, Sorghum, Stakeholders

1. Introduction

Agriculture supports more than 70 percent of the population, constitutes 34.8% GDP [1]. Crops are playing a significant role and it is believed that adoption of new agricultural technologies, such as high yielding varieties, could lead to significant increases in agricultural productivity and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy [2]. Sorghum is an important cereal crop used by humans as staple food grain in many semi-arid and tropical areas of the world [3]. It is the 5th most important cereal crop in the world [4] the 3rd important cereal (after rice and wheat) in India and the 2nd major crop (after maize) across all agro ecologies in Africa

Sorghum (Sorghum bicolor L. Moench) in Ethiopia is the main staple food crop, ranking third after tef, and maize in total production and it ranks second after maize in productivity per hectare [5]. The low productivity of sorghum in the developing countries can be attributed to biophysical, socio-economic and policy related factors affecting directly and

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indirectly sorghum production. Physical Measurements and Improvement Methods of Protein and Other Nutritional Quality Traits of Sorghum [6].

The current sorghum production in Ethiopia is estimated to be 3,604,262 tons on an area of 1,711,485 ha of land giving the national average grain yield of 2.11 tons per hectare [7]. The contribution of improved varieties of sorghum is almost negligible mainly due to poor participation of farmers in the selection process, poor intervention of improved agricultural technologies (absence of improved varieties), birds damage to early maturing varieties, diseases (grain mold, head smut, anthracnose) and insect pests (shoot fly and stalk borer) [8]. Moreover, sorghum is very important cereal in the semi-arid areas of the tropics and sub-tropics in Africa. In Ethiopia, sorghum is a staple food crop widely cultivated in different agro-ecological zones, predominantly in dry areas where other crops can survive least and food insecurity is widespread. Sorghum is the fourth primary staple food crop in Ethiopia after tef, maize, and wheat, both in area coverage, and production. In Ethiopia sorghum is grown in almost all regions occupying an estimated total land area of 1.6 million ha. [9]. A major food and nutritional security crop to more than 100 million people in Eastern Horn of Africa [10]. In Ethiopia sorghum used for making *injera, kitta, kollo* and locally made beverages (such as "*Tela* and *Areke"*).

Generally, the area under sorghum cultivation in Sub-Saharan Africa has steadily increased over the years but the average yield trends are downwards. Paramount among the yield reducing factors is predominant cultivation of inherently low yielding varieties, poor soil fertility, drought, striga, pests and diseases. Exploitation of host-plant resistance through genetic enhancement has always been the first approach or forms the basis of an integrated control package in addressing these constraints. This situation is more reflected in Ethiopia, particularly Benishangulgumuz region, in Assosa Zone in which is local variety well highly utilized and easily affected by striga, poor soil fertility, pest disease and drought. This implies that local sorghum varieties are unable to adapt the climatic change of the current situation and this problem are more aggravated in the area due to moisture stress dominant. To solve the problems, Assosa Agricultural Research Center (AsARC) has conducted based on agroecology adaptation trials and evaluated a number of high yielders, early maturing and striga resistance sorghum varieties in the area. Therefore, to address the problems stated in the above, the agricultural extension research process was supported by second agricultural growth program (AGP II) conducting large scale demonstration in selected woredas in Assosa Zone under the farmers condition through cluster farming approaches. Thus, this activity was aimed to improve smallholder farmers livelihood level, to enhance farmers awareness, access to and adoption of full package of sorghum technologies, and to strengthen linkage between different stakeholder in the region.

2. Methodology

2.1. Description of the Study Area

The activity was carried out in Benishangul Gumuz Regional States, of Assosa zone in Assosa, Bambasi and Homosha districts. Assosa zone is located at a distance of 670 Km from Addis Ababa respectively. It is located on altitude and longitude of 10004'N34031'E/10.0670N34.5170E, with an elevation of 1570 meters above sea level. The mean annual rainfall is 1300 ml. The main rainy season of the zone starts in May and lasts until October. The soil type of the district is silt and sandy soil. Major crops produced in the area include Sorghum, Maize, Finger millet, Teff, Soya bean, Sesame, Groundnut, Rice and horticultural crops. In addition, livestock reared include cattle, goat, sheep, donkey and poultry.

2.2. Description of Assosa-1 Sorghum Variety

Assosa-1 sorghum variety is an improved variety released by Assosa Agricultural Research center in 2015 G.C. The variety is released through collection, characterization and purification of land races from western Ethiopia. It is well adapted to wet lowland and intermediate agro-ecologies of the country including Benishangul gumuz, Western Oromia, Southwestern Oromia, and Gambella and newly formed Southwestern Ethiopia regional states. The variety can also adapt to other areas with similar agro-ecologies with the abovementioned areas. The variety is 75 cm and 15 cm between plant and row. The variety has well identified features with white colored seed, manageable plant height of 2.06 m. Assosa-1 variety takes 139 days to flower and 180 days to reach physiological maturity. The variety can give as high as 38 quintal per hector on research field while it can yield up to 34.5 quintals of produce on farmers' field with farmers practice. The recommended fertilizer rate for the variety is 100 kg/ha of NPS and 50 kg/ha of Urea. The variety is adapted to well-drained clay loam soil.

3. Approaches Used

3.1. Multi Stakeholder Planning Meeting

At the initial stage of the project various stakeholders identified for the multiparty partnership of the innovative approach. The major stakeholders identified in addressing the agricultural technology transfer includes Assosa Agricultural Research Center, Assosa, Bambasi and Homosha districts agricultural and rural development office. After identifying the major stakeholders, participatory planning meeting have been carried out for identification and prioritization of proven technologies to be demonstrated. Task and responsibilities sharing among the institutions with action plan for the activities have been agreed. Subsequently the stakeholders identify the kebeles the technology was demonstrated based on the technology's productivity potential and suitability to the beneficiary's demand to largely demonstrate the selected and identified technologies.

3.2. Site and Farmers Selection

Three districts (Assosa Bambasi and Homosha) were selected from Assosa zone, was selected purposively based on the potential production. From Assosa district five, Bambasi sixe and Homosha three peasant associations/kebeles were selected purposively based on their potential for sorghum production and accessibility. The host farmers were selected in collaboration with Development agents, Agricultural experts and researchers. Farmers were selected based on willingness to conduct the activity, accessibility for supervision, willingness to share experience in the cluster, having minimum of 0.25 ha of land to be clustered. Gender balance in the cluster was considered.

Figure 1. Researchers discuss with Mender 47 & Mender 48 farmers, DAs & district experts at FTC.

Figure 2. Researchers discuss with, A-16 farmers, DAs & district experts at FTC.

Figure 3. Researchers discuss with Mutsa kebele farmers, DAs & district experts at FTC.

Figure 4. Researchers discuss with, M-38 kebele farmers, DAs & district experts at FTC.

Figure 5. Researchers discuss with Womba kebele farmers, DAs & district experts at FTC.

3.3. Cluster Formation

Awareness creation training was given for Farmers, SMSs, and Development agents. Cluster farms were formed depending on the willingness of the farmers, accessibility for adjacent farms, and having the same interest to plant the same crop to the adjacent farmers. Accordingly, farmers were organized in each formed cluster a totally 14 cluster was formed in all districts contains both male and female farmers.

3.4. Methods of Data Collection

Various methods of data collection were used to gather different parameters, feedbacks and perception of stakeholders. Participatory data collection methods including focused group discussion (FGD), interview of key informants, field observation and measurements.

3.5. Data Types

Both quantitative and qualitative types of data were gathered. Quantitative data such as numbers of beneficiary farmers on demonstrated technologies, input used, land size, number of farmers participated in training, field visits and field days by gender and yield data. Whereas qualitative data on feedback and perception from farmers and different stakeholders have been collected and taken.

3.6. Method of Data Analysis

The collected data have been analyzed using descriptive statistics through applying Statistical Package for Social Science (SPSS), and simple Excel sheet. Mean, charts and percentage types of descriptive statistics were used to analyze and describe the collected data.

4. Result and Discussion

4.1. Socioeconomic Characteristics of the Participant Farmers

The average age of LSD participant farmers was forty (40) with a mean farming experience of twenty-nine years. This is basically to mean that, most participant farmers were relatively in active age that may assist them to understand the extension advise and the new technology. The average family size was 5-7, indicates that most farmers had sufficient labor for technology application particularly for row sowing and input application based on recommendation. The educational status of participants also determines extension internalization and technology application. Hence, 56.3% of the farmers were illiterate and the rest were literate from read and write. The participant farmers were allocating the land for large scale demonstration activity from 0.25 to 1 hectare. All participant farmers got training the training provide was sufficient to apply the technology packages. Compared to farmers who usually used backward farming practices, improved technology showed that the frequency of farmland tilling, planting, weed control, and post-harvest handling also had an effect on productivity.

Table 1. Characteristics of participant farmers household in the cluster area.

Variables	Minimum	Maximum	Means
Age / year	25	55	40
Experience / year	18	40	29
Family size/№	5	7	6
Land size/ha.	0.25	1	0.622

4.2. Input Supply and Participants

The required forty (40) qt. of improved sorghum Assosa-1 variety were supplied by Assosa agricultural research center (AsARC) for large scale demonstration for each farmer's field. The activities were demonstrated in 14 clusters covering 339 ha. of land. The LSD addressed 603 farmers; among these 516 males and 87 women were benefited. Seed rate of 10 kg/ha were supply based on the recommendation, Fertilizer was covered by farmers itself applied at rate of 100 kg/ha for NPS and 50/Kg ha for Urea. All agronomic and management practices was applied based on the recommendation.

Table 2. Number of participants, sites, area and seed distributed.

Zone	Crop	Variety	№ of woreda	№ of cluster	№ of farmers involved			Area covered (ha.)	Seed distributed (Qt)
					M	F	T		
Assosa	Sorghum	Assosa-1	3	14	516	87	603	339	40

4.3. Capacity Building Through Training

Training has been organized for farmers, development agents and agricultural experts about the technology package and implementation. The training was given by multidisciplinary team focused on advantage of cluster farming, components of general aspects about the crop and its benefits, all agronomic practices, crop protection and post-harvest handling. A total of 586 farmers and 31 development agents and 9 agricultural experts were participated in the training as mentioned on the graph 1 below. Those stakeholders participated in the training were drawn from different disciplines at the district and kebele level offices.

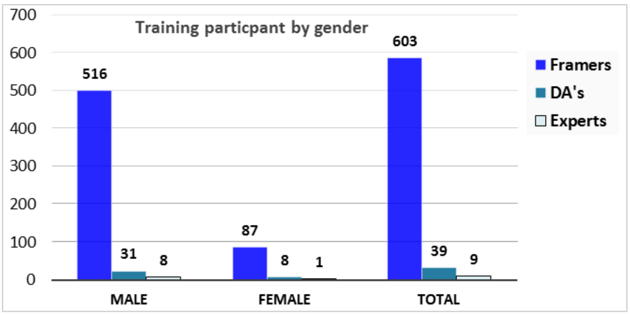

Figure 6. Number of participants on training by gender.

Figure 9. Training for A-13, Nebar komeshiga kebele farmers development agents and experts at on station hall.

Figure 7. Researchers discuss with Mender 47 & Mender 48, farmers, DAs & district experts at FTC.

Figure 10. Researchers, A-16 kebele farmers field prepared for sorghum production with DAs & district experts.

Figure 8. Researchers discuss with Womba kebele farmers, DAs & district experts at FTC.

Figure 11. Farmers field preparation on the field.

Figure 12. Land preparation for sorghum sowing.

4.4. Monitoring and Evaluation

Researchers, extension agents, farmers and expert jointly participated and evaluation at least ones in two weeks to supervise the overall management, progress performance of the variety and others to fill gaps observed starting from site and farmers selection to post harvesting. Comments during the supervision are taken in to account to take any necessary corrective measures and fill the observed gaps.

Figure 13. Performance of the crop on the field.

Field day events

Field day was jointly organized and arranged with woreda agricultural and natural resource office at district level and kebele level so to create awareness on the advantages of the cluster approach farming methods in all implemented kebeles, to create awareness on the importance, accessibility and availability of the technology, to enhance farmers knowledge on improved sorghum production and management and to collect feedback from all relevant stakeholders for further way forward and to increase the productivity of the users. About 1027 participants (700 M and 200 F, 40 M and 10 F experts, 75 M and 2 F higher official) were attend the field day.

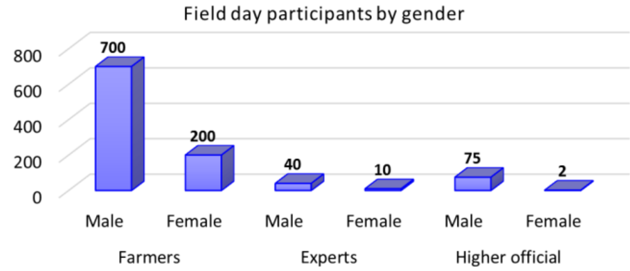

Figure 14. Number of stakeholders participate on field day event by gender.

4.5. Yield Potential and Yield Difference Analysis

Mean grain yield of improved sorghum (Assosa-1) variety in Assosa, Bambasi and Homosha districts was 27 qt/ha., and 30 qt/ha and 31 qt/ha; respectively recorded. The total mean yield of improve sorghum Assosa-1 variety was 28.75 qt/ha. higher than the farmers practice 15 qt/ha. this difference is due to the utilization of best-fit of the variety in the areas and the application of the recommended agronomic practices and field management. From this results it is evident that the performance of Assosa-1 sorghum variety was found better than farmer's practice. From the total of 339 hectare of land 9,990.5 quintal of yield was harvested. This results clearly explained that the farmers practice of grain yield performance was by far lower as compared to grain yield obtained by large scale demonstration. Hence, Large scale demonstration of improved Assosa-1 sorghum variety was recommended to produce in large area in the region.

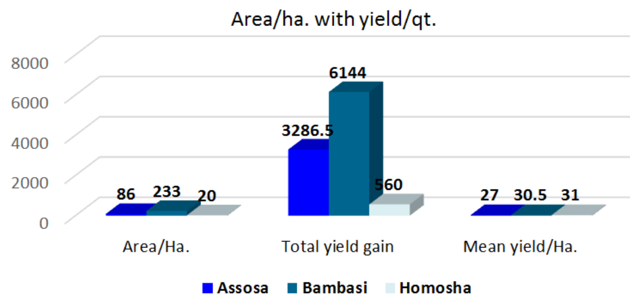

Figure 15. Area of land and yield.

Table 3. Grain yield performance of Assosa-1 sorghum variety performance.

District	Variety name	Potential yield (qt/ha)	Demonstration yield (qt/ha)	Farmer practice yield (qt/ha)	% Yield increment over farmer practice
Assosa	Assosa-1	38	27	14	92.85
Bambasi	Assosa-1	38	30.5	16	90.62
Homosha	Assosa-1	38	31	17	82.35

*Percentage of yield increase over farmers practice = (demonstration yield − farmers practice)/farmers practice) × 100

4.6. Technology Gap and Technology Index

Grain yield gap of Assosa1 improved sorghum variety was analyzed based on the actual implementation and the farmers trend or practice to produce in the selected districts. Based on this the yield gap of Assosa-1 has been explained in terms of technology and extension gaps, technology gap analysis indicates the extent to which technologies have not been adopted well. This feedback data is essential to identify the weakness of the technologies transfer program and to remove bottlenecks and accelerate adoption of improved technologies. Extension gap was analyzed and the result indicated that it need emphasis to strengthen the extension approaches using different types or methods advice, both theoretical and practical training and day to day follow up and experience sharing among farmers to farmers and expert to experts, information dissemination and full technology package supply for the farmers on time. Technology index also calculated this indicate that valued yield at farmers' fields and at demonstration site still have huge potential for yield increments or advantage.

Table 4. Yield potential and gap.

District	Variety name	Potential yield (qt/ha)	Demonstration yield (qt/ha)	Farmer practice yield (qt/ha)	Technology gap (qt/ha)	Extension gap (qt/ha)	Technology index%
Assosa	Assosa-1	38	27	14	11	13	28.95
Bambasi	Assosa-1	38	30.5	16	7.7	14.5	28.23
Homosha	Assosa-1	38	31	17	7	14	18.42

Source; Field data 2020

4.7. Farmer's Feedback

During the feedback assessment participant farmers ware revealed the advantage of the technology. Accordingly, farmers strongly list the advantage of the technology over local variety as well as local practice interims of yield, disease resistant, seed color, striga resistant, good performance on the poor soil fertility, overall stand of the stalk, seed weight, injera making quality, market availability and price. The other farmers appreciate where cluster farming is better to share experience, awareness creation, information share and enhance the strength between farmers equally involved in management practice. Also, the farmer's said: ‘’our interest is increase for the variety because the new sorghum variety is not attacked bay birds than the local sorghum variety and it is more attractive and visible when cluster system is applied”. This indicate that an improved variety will be adopted if the new variety is technically and economically superior to local varieties.

Figure 16. Harvested and collected sorghum on the field.

Figure 17. Harvested and collected sorghum on the field.

4.8. Lessons Learned

During the progression of the work, the team has learned that concerted effort among different actors is instrumental for fruitful work. Thus, identification & collaboration with key stakeholders was one important lesson learned from the process. The other lesson drawn was the importance of using innovative farmers, as their fields speak louder and clearer than researchers. DAs and experts. Thus, using them for technology dissemination is a wise approach to reach the vast majority.

4.9. The Way Forward

The activity conducted demonstrate fruit full result. Consequently, each woreda show their interest and the demand was increase. So, the activity has to be encouraged and expanded more in other woredas of the region and strengthen existing clusters with new technologies.

5. Summary

This large-scale demonstration (LSD) activity was commenced with awareness creation and provision of training to different relevant stakeholders, So, as to build their capacity with regard to promotion of the technology. Furthermore, the successful accomplishment of the works through active involvement of different relevant stakeholders has brought about significant and positive attitudinal change towards partnership and collaboration, thus, built mutual trust and confidence among themselves in promoting their cooperation in other similar joint activities. Generally; the improved Assosa-1 sorghum variety gave higher yield and better benefit than local varieties and practice in the study district where this large-scale demonstration (LSD) activity has been carried out. Thus; by using this improved variety with its full package, farmers can earn more benefit than local varieties and practices. As the variety is preferred by farmers' and other stakeholders' promotion and dissemination of the technology should continue sustainably on wider scope. Eventually; this could be achieved through district agricultural and natural resource offices and other relevant and collaborative stakeholders.

Abbreviations

HHs	Householder's
GDP	Gross Domestic Product
KM	Kilometer
FGD	Focus Group Discussion
SPSS	Statistical Package for the Social Sciences
EIAR	Ethiopian Institute Agricultural Research
AsARC	Assosa Agricultural Research Center
LSD	Large-Scale Demonstration
Ha	Hectare
Qt	Quintal
FAO	Food and Agriculture Organization
CIA	Central Intelligence Agency
CSA	Central Statistical Agency
WB	World Bank
AGP	Agricultural Gross Program

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Author Contributions

Fekadu Begna Chibsa is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

Authors have declared that no competing interests exist.

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