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Pre Scaling up of Improved Faba Bean Variety in Tullo and Gemechis Districts of West Hararghe Zone, Oromia National Regional State, Ethiopia

Mideksa Babu[1*],Temesgen Sime[1],Fekede Gemechu[1] and Asfaw Zewdu [2]
1.Oromia Agricultural Research Institute, Mechara Agricultural Research Center, P.O.BOX 19, Mechara, Ethiopia
2.Oda Bultum University, REALIZE Project, P.O.BOX 226, Chiro Ethiopia

Abstract
Faba bean (Vicia faba L.) is one of the highland leguminous crops and widely sowed in Ethiopia. The productivity of faba bean crop under traditional way of farming system and using local variety is found to be very less. To overcome the production constraint and seed dissemination process, pre scaling up of faba bean was conducted for two years in 2017 and 2018 in two districts of West Hararghe Zone Tullo (Gara kufa kebele) and Gemechis (Walenso Defo and Kuni segaria kebeles). The objectives of the activity were; to enhance production and productivity of faba bean on farmers` fields and to improve linkage among stakeholders and create awareness on improved faba bean varieties. Methodologically, site selection was undertaken by considering criteria like farmers proximity to road for supervision and monitoring purpose, gender balance, farmers which have willingness to technology and sufficient land for the activity and risk taker farmers were selected for the activity. The required data were collected through preparing data record sheet and checklist by interviewing and direct field observation. Data collected were analyzed through descriptive statistics and inferential statistics. Descriptive statistics were used to summarize the yield collected from three locations within two years. Inferential statistics were used to compare the mean yield difference among location by using independent t-test and one way Anova. Concerning the activity extension and advisory services like training and field day were organized for the accomplishment of the objectives of the experiment. Generally, farmers of the study area appreciated accepted the variety to multiply and sow it widely on their farm land for the future. So, it is recommended that the technology should have to get great consideration by district agricultural office to widely distribute it and sustain the use of the improved faba bean technology.
Keywords: Activity, faba bean,Tullo,Gemechis, and scaling up
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INTRODUCTION

Faba bean (*Vicia faba* L.) is a cool season grain legume crop with the potential to be grown as multi-purpose crop in areas with short growing season. Faba bean is grown in many regions in the world due to its high nutritional value, medicinal effect, and effective biological nitrogen fixation. Diverse ecosystem benefits are expected from integrating faba bean in cropping systems (Etemadi et al., 2019). The largest faba bean producer in the world is China with 1.62 Mt. The Mediterranean Basin ranks second with an average in the last decade of 0.67 Mt, followed closely by Ethiopia with 0.62 Mt and at a further distance by France and Australia with0.30 Mt - 0.35 Mt (Rubiales and Fernadez, 2015).

Faba bean has multi-purpose advantage which can be produced for its nutritional and medicinal values. Faba bean grain, pods, and leaves are full of protein and almost all elements required for human diets (Osman *et al*., 2014; Etemadi *et al.,* 2019). It is cultivated for the purpose of both human food and animal feed (Migdadi et al., 2015). The crop contributes to the smallholder farmers as a source of protein in both rural and urban areas (Osman et al., 2014) and is an important source of income for farmers (Merkine and Teshome, 2016).

It is also known by N fixation crop which is considered as high among the grain legumes. Sowing of faba bean within various cropping systems such as crop rotations by cereal crops and intercropping with it improves natural soil fertility and reduce the consumption of commercial N fertilizer, to minimize the occurrence of cereal cyst nematode (*Heterdera avenae*) and soil-borne pathogens (Landry *et al*., 2016; Etemadi *et al.,* 2019).

Faba bean is partially a self-pollinating plant; however flowers attract various pollinators, specifically honey bees. Recent study indicated that honey bees and other natural pollinators can increase the pollination incident and thus grain yield in faba bean (Marzinzig *et al.,* 2018).

The production and productivity of faba bean are constrained due to soil fertility decline and soil acidity, among other factors (Endalkachew *et al*., 2018). The productivity and yield of the crop is still far below its potential due to lack of improved varieties and application of inadequate agronomic practices (Merkine and Teshome, 2016). Even though there is challenge to production of faba bean, about 437,106.04 hectares of land were covered by the crop which accounted that the distribution of 3.45 % in 2017/2018 cropping season (CSA,

2018).

The productivity of faba bean varieties under traditional way of farming system is found to be very less (Fekede et al, 2018). However there is an opportunity to use improved technology like improved seed, organic and inorganic fertilizer and appropriate agronomic practices in enhancing its production. Taking into account the scenario of the study area, Mechara Agricultural Research Center has conducted Participatory variety selection of different improved varieties which are developed by different research centers.

From the adapted varieties the center recommended two varieties namely, Hacalu and Tumsa for demonstration on farmers` fields. In 2015 to 2016 Hachalu and Tumsa varieties were evaluated with local variety with different parameters on farmer's field. The evaluation result indicated that Hachalu variety was performed well in considered parameters and recommended it for further scaling up in study area and with in similar agro ecology. Thus, this study was initiated with the objectives of enhancing production and productivity of improved variety of Faba bean in the study area, strengthening linkage among actors and partners by creating rate of dissemination and improves farmers' knowledge and skill on Faba bean production.

Objectives of the study

- To enhance production and productivity of faba bean on farmers` fields;
- To improve linkage among stakeholders and create awareness on improved faba bean varieties

Review of Faba Bean Production in Ethiopia

Ethiopia is one of the fundamental centers of faba bean diversification. There are some evidence which shows remarkable diversity in protein content, chocolate spot and leaf rust resistance (MoA, 2010). Faba bean production and productivity are affected mainly by biotic factors (diseases, insect pests, and parasitic weeds). Faba bean irritate disease, a new disease in Ethiopia, is the major and the most widespread and destructive disease in the faba bean growing area (Getnet and Yehizbalem, 2017).

The major faba bean producers in Ethiopia are Tigray, Gondar, Gojjam, Wollega, Wollo, Gamo, Gofa, and Shoa (MoA, 2010).There also so many released improved variety of faba bean in Ethiopia which are under production and newly recently released by research centers and at higher education. Despite the availability of improved varieties and associated crop management practices, availability and access to these technologies are limited resulting in low productivity. The yield gaps between research managed and national yield levels are still very high across all crops and agro-ecologies including faba bean (Spielman *et al*., 2010). Likewise, the performance of formal seed sector also varies considerably by crop type and agro-ecology where legume seed supply in general and faba bean in particular is very weak.

Overview Production of Faba Bean in Western Hararghe Zone

Faba bean is one of the most known highland crops in West Hararghe zone. It is produced majorly in Tullo, Chiro, Gemechis and Guba Koricha. The farmers of area used majorly the local variety to produce it for both consumption and commercial purpose. But, after intervention was made by research the farmers gets the opportunity to use the improved variety released by research centers. In 2014, participatory variety selection (PVS) was done by Mechara Agricultural Research Center to select the best performed variety by different selection criteria with the full participation of farmers. The experiment was done on farmers land with some variety to evaluate and select for farmers and by farmers (Wondimu *et al.,* 2016).

Among the evaluated variety hachalu and tumsa varieties were selected by farmers and experts with the major parameters sated by researchers, experts and farmers. Following the PVS experiment the selected varieties of Hachalu and Tumsa were taken for demonstration by researchers in three location of West Hararghe Zone,namely Chiro,Gemechis and Tullo districts in 2016 to 2017. From the demonstrated and evaluated varieties hachalu were performed well and selected for further scaling up by researcher and farmers in similar agro ecologies to the study area (Fekede *et al*., 2018). Production and productivity as well as yield of the crop may be affected by drought and management practices (Asfaw *et al*, 2018; Fekede *et al.*, 2018). The yield overview of hachalu variety was shown by the figure 1.

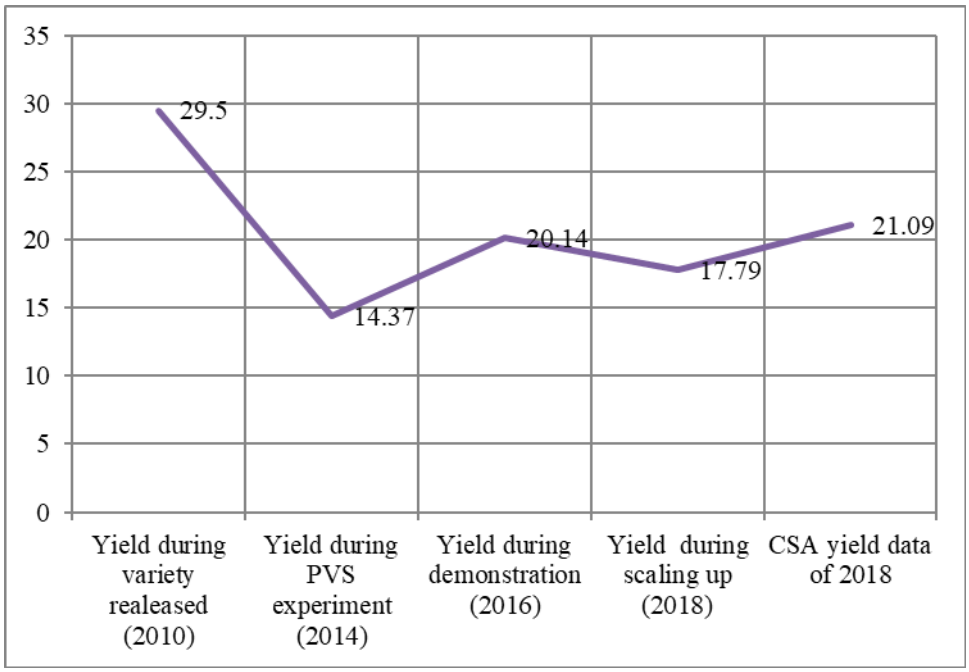

Figure 1: yield overview of hachalu variety in West Hararghe Zone

RESEARCH METHODOLOGY

Description of the study area

Pre scaling up of faba bean was undertaken in 2017/2018 to 2018/2019 in Gemechis and Tulo districts of the West Hararghe zone of the Oromia National Regional StateGemechis district is one of the seventeen districts in West Hararghe zone, which is located at 343 km East of Addis Ababa and about 17 km South of Chiro, which is the capital town of the zone. The district is situated at the coordinate between 8^0 40'0" and 9 ^{0}04'0" N and 4^0 50'0" and 41^0 12'0" E. The soil of the study area was dominantly loamy soil (Desalegn *et al*., 2016). Gemechis town is located on the top of a hill and its climate is 70% cold and cloudy. The woreda has many small cities located 20–45 miles away from each other. Sogide, Sire, Metadhab, and Degaga are the major ones. Transportation for commuting is a major problem of the woreda.

Tulo district has 45,670 hectares of land area and located 370km southeast of Addis Ababa. The altitude of the district is 1750 meters above sea level with mean annual rainfall of 1850ml and mean annual temperature of 23°C. The production system is mixed type in which extensive husbandry management of livestock have been practiced (Tulu D and Lelisa K, 2016).

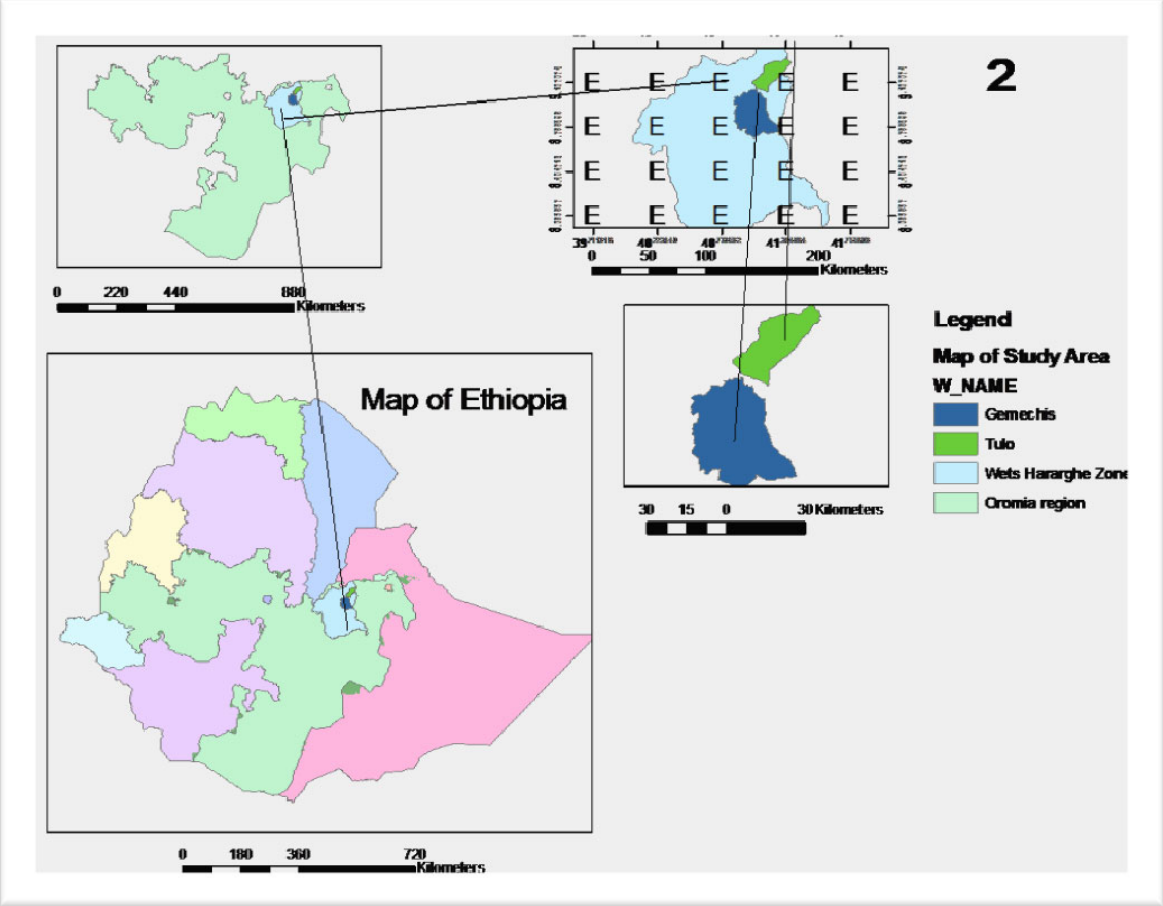

Figure 2: Map of the study area
Source: Own design from Arcgis data (2018)

Farmers and Site Selection

The activity was conducted for two consecutive years in Gemechis (2018/2019) and Tulo (2017/2018) districts of West Hararghe zone. Expert meeting and desk study were undertaken for site and farmer selection. Thus, major faba bean producing *kebeles* and farmers were selected in collaboration with district Agricultural Office. Accordingly, two *kebeles* from Gemechis district (Walenso Defo and Kuni segaria *kebeles)* and one kebele from Tullo district (Gara kufa kebele) selected purposively based on faba bean production potentials. The summary of selected participants for the activity was discussed by the table 1 with the area covered and amount of seed delivered.

Table 1.Summary of inputs procured to the farmers

District	*Kebeles*	Varieties	Farmers	Amount given (Qt)	Area covered (Ha)
Tulo	Gara kufa	Hacalu	18	1.8	2.25
Gemechis	Kuni segaria	Hacalu	28	2.8	3.5
	Walenso defo	Hacalu	26	2.6	3.25
Total			72	7.2	9

Source: Own field data (2018)

Agronomic Practices applied

All agronomic practices and packages of technologies required for the varieties have been applied on farmer's field. But, all farmers did not apply the agronomic practices required for the varieties on their field. Broadcast sowing; reduce number of seed rate and increasing and decreasing farm allocation to faba bean varieties are problems observed on some of farmer's field.

Seed rate used
The optimum plant population of faba bean for maximum pod and grain yield as well as N fixation is not well documented (Etemadi *et al,* 2019). Kissi *et al*. (2016) showed that the seed rate of 250 kg/ha at onset of rain shower recorded maximum seed yield than the other seed rates. But, Ethiopian crop variety register recommended the seed rate of hachalu variety 275kg/ha (MoA, 2010).

Land preparation
Before preparing the land appropriate site for faba bean crop is needed to be selected. In addition the selected site and land is required to be cleared. Land clearance is important for avoiding the emergence of weed in the land wanted to be cultivated on it. Land was required to prepare well by digging it two to three times before sowing the seed. Concerning the prescaling of faba bean activity the researcher has prepared the checklist during the supervision time to take some data like frequency of cultivation, land history/previously sowed crop and frequency of weeding. Thus, majority of farmers cultivated their land more than two to sow the seed of faba bean variety (hachalu).

Land history (previously) sowed crop
Crop rotation of faba bean with other crop especially with non-leguminous crop is very known to increase soil fertility (MoA, 2010). Sowing of faba bean within various cropping systems such as crop rotations by cereal crops and intercropping with it improves natural soil fertility (Landry *et al*., 2016; Etemadi *et al.,* 2019). It obtained from supervision data as the majority of farmers previously planted potato and onion in study area before sowing of faba bean. This shows that the farmers of the area rotate faba bean crop production with potato and onion especially in Gemechis district.

Sowing methods
After the land was prepared well, faba bean seeds should be sowed about 2.5 cm deep and the distance between plants on planting rows is 15 to 23 cm, depending on row spacing (Etemadi *et al*., 2015).

Weeding
One of the yield enhancements is undertaken through proper management of the crop like weeding and thinning out. As the data was taken from farmers during supervision, the beneficiary of the activity mean that the farmers participated on the activity managed their faba bean land by weeding at least two times to get the expected yield from it.

Types and Methods of Data Collection
Qualitative and quantitative data were collected through close supervision and following up of the activity with joint action of the stakeholders. Data record sheet has been developed to collect the data. Thus, field observation, contacting the target farmer and focus group discussion during the field visit were the data collection methods. Agronomic data such as yield data and farmers' preference toward the variety were collected from farmer's field.

Methods of Data Analysis
Qualitative data like farmers' preference analyzed by descriptive analysis and narration while quantitative data analyzed by using SPSS v.20 software.

Method of communicating the result
Field days, building local farmer to farmer networking, training and print materials (Leaflets, banners, posters, mass media/TVO, etc) were the methods of communicating the result in order to create impact in the project location.

RESULTS AND DISCUSSIONS

Yield Performance of Hacalu Variety
Prescaling up of faba bean was undertaken for two years in 2017 and 2018 in two districts of Tullo and Gemechis. Faba bean variety of hachalu was distributed to 18 farmers in Tullo district in 2017 at Gara kufa *kebele*. In 2018 the seed was distributed in Gemechis at two *kebeles* of Walenso Defo and Kuni Segaria besides 26 and 28 farmers respectively. The seed was sown by row sowing methods on the area recommended and managed by farmers to achieve the objectives of the activity. The combined mean of the crop collected in two years from both districts were discussed by Table 5. The combined mean of the grain collected from three locations Gara Kufa, Kuni Segaria, and Walensio Defo are 17.79 quintal/ha and with standard deviation of 10.27.The total yield of the grain yield collected from both districts from 268 ha are 1191quintal.The mean yield gained from the activity is less than the the mean yield gained from demonstration which is 20.14 quintal/ha

(Fekede *et al*., 2018) and better than the mean yield gained from PVS which is 14.37 quintal/ha (Wondimu *et al.,* 2016). Mean yield gained from CSA data in 2018 shows faba bean recorded 21.09 quintals. So, the mean yield gained from scaling up is less than the obtained yield by CSA in 2018.

Table 2: Mean yield of faba bean varieties in study area

Variety	No. of farmers	Mean yield from ha/Qt	Std. Deviation
Hacalu	67	17.79	10.27

Source: Own computation (2018)

Tekle *et al* (2016) discussed in his study that Hachalu variety gave 30.37 quintal/ha which is better than the yield gained by our study. Yield gap is occurred due to different reasons. But the actual potential yield of the hachalu variety during its released time is 29.5quintal/ha (MoA, 2010). The reasons which might cause the yield difference are like management difference among farmers from place to place, rainfall pattern, disease occurrence, soil fertility/type and the like. In 2018 when the activity was conducted in Gemechis district the rainfall was not sufficient especially at maturity stage. So, it is believed that the main reason that causes the occurrence of minimum yield is inadequacy of rainfall in study area during its critical stage.

Comparison of Yield Collected From District

Yield comparison across districts

Production and productivity of crops and yield difference occurred from place to place due to management practices (weeding and thinning out), input used like fertilizer, environmental conditions, farmer's indigenous knowledge on farming, soil characters, extension services, infrastructure and others factors (Asfaw *et al*.,2018). High mean yield were obtained from Tulo district in 2017 which is 24.37quintal/ha than Gemechis district that is 16.20 quintal/ha (Table 4). There is also significant difference between the yields gained from both district at 1% significance level.

Table 3: Grain yield of the variety (Hacalu) across district by year.

District	N	Mean yield	Std. Deviation	t-value	Sig.
Tullo (2017)	13	24.37	9.10	2.694***	0.009
Gemechis (2018)	54	16.20	9.98		

***Sign shows that the study is significant at 1% significant level

Source: Own computation (2018)

Yield comparison adjacent to location(*kebeles*)

Table 4a: Mean yield comparison among the three *kebeles*

Comparison	Sum of Squares	Mean Square	F	Sig.
Between Groups	2863.142	1431.571	22.361	.000
Within Groups	4097.283	64.020		
Total	6960.425			

Source: Own computation (2018)

As it was discussed earlier pre scaling up of faba bean variety (hachalu) was done on three locations within two year. The results of the mean yield among the three locations were compared by one way Anova (Table 5). Table 5 indicated that there is significant difference among the three locations. Thus, it can be easily understood that there is variation in mean yield of the crop against the locations which may be the result of natural and human factors. The natural factors like unevenly distributed rain fall, drought, heavy rain (ice) and heavy air condition (wind). Mean yield variation of the experiment can also occur due to human factors like inability to manage properly the experiment starting from land preparation to harvest.

Table 4b: Mean yield comparison among the three kebeles

Multiple Comparisons

Dependent Variable: grain yield

	(I) kebele of activity	(J) kebele of activity	Mean Difference (I-J)	Std. Error	Sig.
LSD	Gara Kufa	Kuni Segaria	14.26923*	2.68534	.000
		Walenso Defo	1.60000	2.71789	.558
	Kuni Segaria	Gara Kufa	-14.26923*	2.68534	.000
		Walenso Defo	-12.66923*	2.17916	.000
	Walenso Defo	Gara Kufa	-1.60000	2.71789	.558
		Kuni Segaria	12.66923*	2.17916	.000

*. The mean difference is significant at the 0.05 level.

Source: Own computation, 2018

Capacity Building organized for Stakeholders

Training

Besides advisory services, training is prepared for the farmers, extension agents and agricultural experts on faba bean agronomic practices, production and pre-harvest and post-harvest managements to improve knowledge, skills and attitudes of trainees (Asfaw *et al*., 2018). As indicated in Table 6, a total of 15 farmers, 9 extension agents and 7 agricultural experts were participating in training program. Due to budget shortage, all farmers did not participate in training program. Out of 72 faba bean producer farmers, 9 model farmers are selected by different criteria's such as role model, ability to transmit information, communicator and others. Extension agents and participant farmers are transmitted information shared from training to the non-participant farmers. Participatory training method is followed during implementation of training program for sharing knowledge's, skills and experiences own on faba bean productions.

Table 5: Training provided for participants on faba bean production and management

Districts	Farmers			Development Agents			Experts		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Gemechis	6	4	10	3	1	4	2	1	3
Tullo	3	2	5	2	1	3	2	1	3
Total	9	6	15	5	2	7	4	2	6

Source: Own field data (2018)

Field day

According to Asfaw *et al.* (2018) field day is one of extension services and methods used to transmit information and awareness creation for larger audience. Field day can be organized at different stages in crop production systems. It can be two or three times which the stages are at vegetative, flowering and maturity depending on crop type and nature produced. Field day is used as tool to address large number of farmers, even invited farmer who did not produce improved faba bean varieties to create massive awareness and large impacts on technologies for further production and scale up on farmers field. Not only farmers but also others stakeholder are also invited to participate on the program. In addition, during field day mass extension methods e.g. leaflets, banner are used to reach large audience.

Accordingly, a total of 62 farmers, 9 development agents and 4 experts from district government offices and research office were participating on field day (Table 7). A total of 70 leaflets are distributed for the participants which describes the production, agronomic practices and overall managements of improved finger millet varieties.

Table 6: Participants of field day in Gemechis district

Location of field day	Types of varieties	Participants								
		Farmers			Development Agents			Experts		
		M	F	T	M	F	T	M	F	T
Gemechis		57	5	62	8	1	9	4	-	4

Note: M stands for Male, F stands for Female and T stands for Total

Source: Own field data, 2018

Stakeholder Analysis and Farmers Feedback on the Technology

Stakeholder analysis

Pre scaling up of faba bean was conducted with participation of researcher, extension expert from district agricultural office, agronomist from district agricultural office, development agent and farmers. All of the stakeholders were contributed their own role to achieve the objectives of the activity starting from planning to its implementation stage as discussed in the Table 8. The following table reveals roles and responsibilities of each and every stakeholder in implementation of the activity.

Table 7: Responsibility sharing among stakeholders

Activity/materials	**Responsible stakeholders'**
Land and labor	Farmer
Site and farmers selection	Agricultural districts office and McARC
Land preparation, sowing, weeding, harvesting and trashing	Farmers and DA's
Data collection and supervision	Researcher and DA's
Providing improved seed	McARC
Providing training	Researchers
Preparation of field day	Researchers, DAs and Focal Persaon
Report writing	Researcher

Farmer's feedback on the technology

Farmer's feedback on the technology was collected from its emergence to threshing. From farmers point of view hachalu variety of faba bean has good germination, disease resistant, has good stand, and has uniformity in stand, very attractive in eye & beauty on field. During demonstration stage hachalu variety were selected as first by different parameters like plant establishment, seed size, number of branches, disease resistant, plant height and grain yield (Fekede *et al*., 2018).

Finally, at the end of visit during field day, group discussion is conducted to grasp farmer's feedback on strength and weakness of improved faba bean varieties. Besides, constraints in agricultural production (weeds like straiga wilt on chickpea and climate change); needs and interest of farmers on others improved varieties such as early maturing sorghum and chickpea and timely distribution of seeds are points rose by participants on the program. Accordingly, Hachalu variety is more preferred than local variety due drought tolerance and yield advantages. Generally, majority of farmers appreciated the variety and has full willingness to sow it widely by giving more land for this crop separately.

Exit Strategy

It is obvious that technology dissemination has its own procedure starting from variety development to its extension. Improved variety of faba bean also developed by Holeta Agricultural Research Center in 2010 (MoA, 2010). Its adaptation (PVS) was done by Mechara Agricultural Research Center in 2014 (Wondimu, 2016). After PVS the experiment was taken to on farm demonstration for evaluation purpose in 2016 (Fekede *et al*., 2018). Its scaling up was also done on sixty seven farmers (67) on two district in 2017 and 2018.

As exit strategy memorandum of understating were signed between farmers and development agent to sustain the production of this improved variety. Awareness creation was also made as the technology disseminated through farmer to farmer technology dissemination system. In addition the copy of signed memorandum of understanding were given to district agricultural office as they follow and monitor the status of the technology for full adoption purpose.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Pre scaling up of faba bean was conducted for two years in 2017 and 2018 in two districts of Tullo (Gara kufa *kebele)* and Gemechis (Walenso Defo and Kuni segaria *kebeles*). Concerning the activity extension and advisory services like training and field day were organized for the accomplishment of the objectives of the experiment. In implementation of the activity the required inputs like seed rate, fertilizer and labor required were applied. Agronomic practices such as cultivation, sowing methods (row sowing) and weeding were done by farmers.

Yield summary of the three locations was also discussed from the results of the finding. From the activity high mean yield were gained from Tulo district in 2017 which is 24.37quintal/ha than Gemechis district that is 16.20 quintal/ha as it was revealed in the results of the finding. Yield comparison was also seen between district and among the *kebeles* by independent t-test and One-way Anova respectively. Thus, the result of the study shown that there is the significant mean yield deference between district and among *kebeles* at 1% significant level. So, it can be concluded that there is yield difference from place to place depending on different factors like human and non-human factors. The non-human (natural) factors like unevenly distributed rain fall, drought, heavy rain (ice) and heavy air condition (wind). Mean yield difference of the experiment can also occur due to human factors like inability to manage properly the experiment starting from land preparation to harvest. Generally, farmers of the study area appreciated accepted the variety to multiply and sow it widely on their farm land for the future.

Recommendations

From the result of the study the following recommendations are given:

- To bridge the yield gap observed among different study and to get its potential yield the farmers should give proper management for improved technology of faba bean.
- To sustain the use of the improved variety of faba bean district agricultural office should follow and monitor its adoption status.
- Farmer to farmers seed dissemination pathway should also arranged by the concerning body to expand the technology widely.
- Market linkage should have to be made in enhancing the efficiency of the technology

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