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# On-farm Demonstration of Improved of Faba Bean (*Vicia faba* L.) Highlands of Southwestern, Ethiopia

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

Participatory pre-extension demonstration was taken in Dedo and Bedele woreda, in Jimma and Buno Bedele zone in two kebeles each in 2018 main cropping season. Data were collected 100 plants from the demonstration plots. From this study, the performance of three improved fababean and one local variety collected from the areas serves as a check were tested in 11 farmers demonstration plots in two districts of southwestern Ethiopia. From the agronomic traits includes: Days to flowering, days to maturity, plant height (cm), harvest index (%), 1000 seed weight and yield and yield Mean grain yield of the tested varieties ranged from 2200 Kg/ha for local variety, to 4370 Kg/ha for Dosha with overall mean value of 3450 Kg/ha. In addition, the highest agronomic performance was recorded for most agronomic traits. In terms of thousand seed weight, the variety Tumsa (805.80 g) score the highest next to Gora (896.60 g).The farmers preference selection and three development agents, 8 men and 5 women farmers evaluated the trial using plant earliness, biomass, seed size, number of branches per plant, plant height and the disease reaction are used

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as a criteria to select promising varieties Tumsa (23.00), Dosha (16.94) and Gora (16.83) scored up to three highest values, respectively. The lowest (8.96) was scored for the local variety**.** From agronomic data at two districts in participation of farmers, Dosha, Gora, Tumsa and local variety fababean varieties were given superior in grain yield respectively. The study also showed that Dosha superior in other agronomic traits except thousand seed weight and harvest index. From the farmer's preference Tumsa, Dosha, Gora and local variety ranks up to fourth. Therefore, all the three improved varieties with their agronomic packages selected by farmers are recommended for Dedo and Bedele districts Southwestern Ethiopia and similar highland agro ecology.

*Keywords: Faba bean; selection; varieties; criteria; participatory approach; demonstration plots.*

## 1. INTRODUCTION

Faba bean (*Vicia faba L.)* is one of the most popular leguminous crops in Ethiopia. Fababean production for food and feed was 4.5 million tones worldwide in 2019. Faba bean is one of the most important food legumes ranking fourth in the world, after field pea, chickpeas and lentil. The world area of fababean production is 2.5 million ha [1]. Ethiopia is the leading producer of fababean in Africa with a share of 1.5 million metric ton in 2013 [1]. The productivity of improved varieties is very high (3.5 t/ha) compared to the country average yield (1.8 t/ha) [2].

Fababean can be grown where annual rainfall is between 1000 mm and 1100 mm, and consistently distributed during the growth season. In Ethiopia, fababean can be grown above 1800 meters above see labels and up to an altitude of 3000 m.a.s.l (MOA, 2015). In above and lower rages it can be affected by frost at higher range and in lower range can be affected by rust and powdery mildew. Fababean does better on deep, well-structured clay soils but it can grow on a wide range of soils provided they are not too acidic (pH form 6-8) or saline.

Ethiopia, with the current estimated population of 114,963,588 million which grows at a rate of 2.66% in 2020 and by 2050 it will expected to be 205,410,675(https://www.worldometers.info/world-population/ethiopia-population/), has one of the world's highest incidences of malnutrition. Agriculture is the mainstay most important source of livelihood employing 80% of the labor. In Ethiopia, 492,271.60 hectares, 3.30% pulse share, were planted and a production of 10,419,535.14 quintals were obtained with 21.17 /ha national productivity [3]. Oromia regional states, fababean are cultivated in mid highland to highlands of the region occupies about 66,590.48 hectares of land annually with estimated production of 1,091,411.71 quintals (CSA, 2014/2015). The regional (16.39 qt/ha) average yield of faba bean has remained low (CSA, 2014/2015). Even though the crop has a number of potential uses, the productivity of the crop is far below the potential and is constrained by use of low yielding varieties, unequal distribution of rain fall, poor agronomic practices, prevalence of insect pests and diseases, declining of soil fertility and acidity problems.

Research activities were more directed to develop high yielding varieties with improved level of resistance to biotic and abiotic stresses under different agro-climatic conditions. Demonstration farms have a long tradition and have proved to be effective means of addressing problems and testing solutions at the farm level [4,5]. Demonstration farms have a long tradition and have proved to be an effective means of supporting farmers in problem solving at the farm level [6]. On farm demonstration is an effective and proven method to share new information indirectly. They are demonstration events that occur on a farmer's field or other farm location so that participants can see or practice a new technique or technology. The demonstration can display the results of adopting a new practice or give farmers a chance to practice new techniques or methods. Several demonstration works confirmed that leguminous crops show remarkable growth and yield response varietal difference in different agro-ecologies in Ethiopia [7,8]. Therefore the objective of this paper is to deliver farmers, extension workers and seed producers with standardized and simplified varieties for users; to demonstrate and popularize the high yielding fababean released variety/varieties to know farmers preference and selection criteria and to promote small scale fababean production and enhance the adoption of the technology.

## 2. METHODOLOGY

### 2.1 Description of the Study Area

The study was conducted for one year in Bedele and Dedo districts of Buno Bedele and Jimma

zone respectively. Degija and Uregesa *kebeles* from Bedele district and Situ and *kebele* from Dedo district were purposively selected depending on their fababean production potential.

## 2.2 Farmers and Site Selection

Eleven farmers and one Farmer training center were selected based on their interest to the technology, model farmers, managing the experiment and have appropriate land for the experiment.

## 2.3 Experimental Design

Three improved faba bean varieties namely Dosha, Tumsa, Gora and one local were demonstrated and evaluated with local variety. The experiment was demonstrated on 20 m by 40 m (800 $m^2$) demonstration plots and DAP 100 kg/ha at the time of sowing were applied to each demonstration plot with recommended seed rate. Seeds were planted in rows of 40 cm spacing and drilled at 10cm.The required management like weeding and thinning out were done as per the recommendation for improved and farmer's practices for the local checks.

The demonstration field is divided into plots containing the set of technologies to be shown to farmers. The experiment consists of eleven soil sample were collected from the experimental site at the depth of 0-20 cm using an auger.

## 2.4 Materials Used for the Experiments

Three improved varieties *viz*., Dosha, Tumsa, Gora and one local was used for the details (See Table 2).

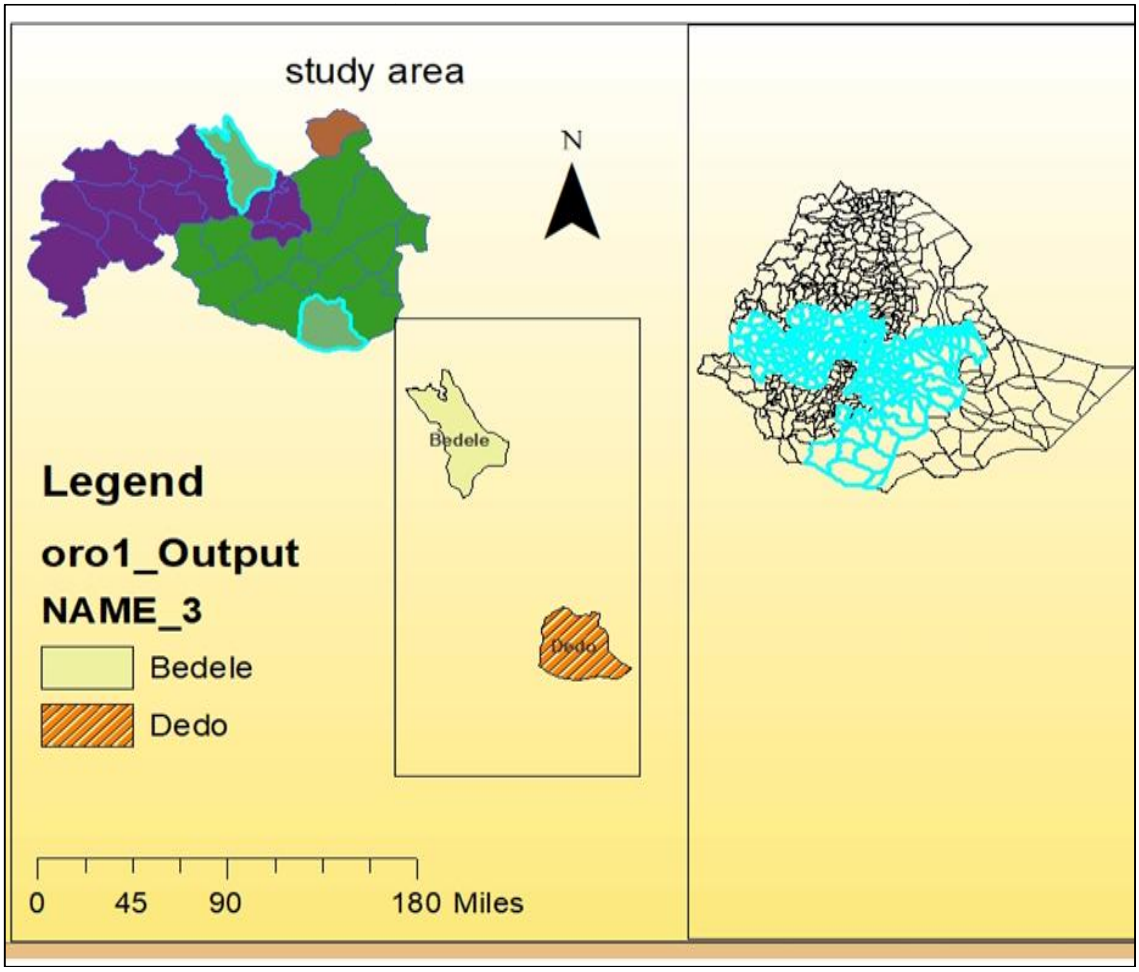


**Fig. 1. Map study area**

**Table 1. Shows experiment location, farmers participated, area covered and varieties used in study area**

| Locations (Woreda) | Zone(s) | Kebele | Coordinates GPS location | Altitude (m.a.s.l) | Number of trial farmers | Varieties | Area covered($m^2$) |
|---|---|---|---|---|---|---|---|
| Dedo | Jimma | Elala | 729'931"N036°51'477"E | 2395 | F1 | Tumsa | 40*40=1600 $m^2$ |
| | | | 729'654"N036°50'188"E | 2398 | F2 | Dosha | 20*40=800 $m^2$ |
| | | Sito | 729'930"N036°51'470"E | 2325 | F3 | Dosha | 20*40=800 $m^2$ |
| | | | 729'931"N036°51'477"E | 2328 | F4 | Tumsa | 23*37=851 $m^2$ |
| | | | 729'921"N036°51'478"E | 2326 | F5 | Tumsa | 20*40=800 $m^2$ |
| | | | - | 2320 | F6 | Local | 20*20=400 $m^2$ |
| Bedele | BunoBedele | Digeja | 829'157"N036°21'610"E | 1916 | F7 | Tumsa | 20*40=800 $m^2$ |
| | | Urgessa | 829'931"N036°21'932"E | 1914 | F8 | Tumsa | 18*31=558 $m^2$ |
| | | | 829'690"N036°21'970"E | 1913 | F9 | Dosha | 20*40=800 $m^2$ |
| | | | 829'933"N036°21'478"E | 1992 | F10 | Gora | 25*30=750 $m^2$ |
| | | | - | - | F11 | Local | 20*20=400 $m^2$ |

**Table 2. Performance of the fababean varieties used for the experiments**

| Nº | Variety | Pedigree | Year of Release | Crude Protein (%) | On station grain yield (t $ha^{-1}$) | On farm grain yield (t $ha^{-1}$) | Thousand seeds weight(gm) | Adaptation altitude(m.a.s.l.*) |
|---|---|---|---|---|---|---|---|---|
| 1. | Dosha | COLL155/00-3 | 2008 | 26.5 | 2.8-6.2 | 2.3-3.9 | 704 | 1800-3000 |
| 2. | Tumsa | EH99051-3 | 2010 | 26.5 | 2.5-6.9 | 2.0-3.8 | 737 | 2050-2800 |
| 3. | Gora | EK01024-1-2 | 2013 | 24.0 | 2.2-5.7 | 2.0.4.0 | 938 | 1900-2800 |
| 4. | Local | Landrace | - | - | - | - | - | - |

**m.a.s.l=meters above see labels*

**Table 3. Physical and chemical properties of the soil sample taken from Dedo and Bedele Districts from South western Ethiopia in 2018**

| SN | Farmers name code | Result/Parameter tested | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | pH(1:2.5) | Available P (ppm) | Total nitrogen (%) | Organic carbon (%) | Ex. acidity (meq/100 g) | % sand | %clay | %silt | Textural class |
| 1 | 101 | 4.72 | 7.76 | 0.14 | 2.12 | 1.66 | 51 | 38 | 11 | Sandy Clay |
| 2 | 102 | 4.83 | 6.82 | 0.13 | 1.84 | 0.23 | 55 | 26 | 19 | Sandy Clay Loam |
| 3 | 103 | 4.75 | 5.1 | 0.13 | 2.32 | 0.29 | 53 | 40 | 7 | Sandy Clay |
| 4 | 104 | 4.54 | 3.38 | 0.23 | 2.28 | 0.6 | 57 | 30 | 13 | Sandy Clay Loam |
| 5 | 105 | 4.69 | 5.02 | 0.25 | 1.88 | 0.59 | 47 | 44 | 9 | Sandy Clay |
| 6 | 106 | 4.57 | 3.53 | 0.32 | 2.09 | 0.33 | 67 | 24 | 9 | Sandy Clay Loam |
| 7 | 107 | 4.64 | 4.47 | 0.19 | 1.99 | 0.25 | 59 | 32 | 9 | Sandy Clay Loam |
| 8 | 108 | 4.74 | 5.02 | 0.14 | 2.05 | 0.18 | 53 | 42 | 5 | Sandy Clay |
| 9 | 109 | 4.58 | 3.53 | 0.16 | 2.19 | 0.27 | 61 | 28 | 11 | Sandy Clay Loam |
| EIAR/RL/ JARC/ SOP5.4-2 (water suspension technique) | | EIAR/RL/JARC/ SOP5.4-6 (Based on Bray II) | EIAR/RL/JARC/ SOP5.4-5 (Based on Kjeldahl technique) | EIAR/RL/JARC/ SOP5.4-4 (Based on Walkley Black | EIAR/RL/JARC/ SOP5.4-3 (Based on1M KCl extraction | EIAR/JARC/SOP5.4-9 (Hydrometric) using NSRC/EIRO/PSPA Manual | | | | |

## 2.5 Data Collection Methods

### 2.5.1 Soil sampling and analysis

The soil's physical and chemical characteristics of the study area shows (Table 1) that with the dominance of about 75% sand, and low silts (10%) contents, the soil was sandy loam. The pH was slightly acid. Cation exchange capacity, Ca, Mg, and K were moderate and BS was high. Total N was low (0.16%) 15 but available P was moderate (4 mgkg−1). The area has been left fallow years before the conduct of the research so the area had relatively high nutrients especially the exchangeable cations.

Post-harvest soil samples (0-20 cm depth) were collected from five spots diagonally and composited. Composited soil sample was prepared following standard procedures and analyzed for soil pH, organic carbon, total nitrogen, available phosphorus and cat ion exchange capacity (CEC), and textural class. After harvest, soil samples were also collected from each plot and composited treatment wise for the determination of phosphorus. The analysis determination method for each analysis described as Table 2. Agronomic data, days to flowering, days to maturity, plant height (cm), harvest index (%) and yield and yield components were taken from 100 plant sample from each farmer. During the growth season and before maturity, the following data were recorded at maturity stage (green pods), the following measurements were taken from each varieties by harvesting 100 randomly selected plants from each farmers:

1. Plant height: From ground level to the plant shoot tip.
2. Number of branches on the main stem: from basal and mediated nodes.
3. Number of pods per plant: Was measured as the average of five plants.
4. Number of seeds per pod: Was counted for ten random pods.
5. 1000-seed fresh weight: Determined by mixing the whole samples, then 1000 seeds were randomly counted and weighted.

Beside this, farmer's preference were assessed and collected. Farmer's preference ranking of the tested varieties was made based on the perception of the farmers' evaluation criteria. A scale of 1-5 was used to compare their preferences in a manner indicating that higher preference =1, lower preference=5 [9]. CIMMYT partial budget analysis and pair wise and matrix rankings were used to analyze farmer's preferences criteria.

## 2.6 Statistical Analysis

The collected data were analyzed using GenStat 13 statistical software (GenStat Thirteenth Edition, 2010). Mean separation was carried out using Least Significant Difference (LSD) test at 5% probability level (Steel and Torrie,1980). Farmer's selection data were analyzed using simple ranking method in accordance with the given value (De Boef and Thijssen, 2007).

## 3. RESULTS AND DISCUSSION

### 3.1 Crop Performance on the Farmer's Field

Mean grain yield of the tested varieties ranged from 2200 Kg/ha for local variety, to 4370 Kg/ha for Dosha with over all mean value of 3450 Kg/ha. In addition, the highest agronomic performance was recorded, including number of pod per plant, number of seed per plant, plant height, fresh biomass weight(g) for the variety Dosha except in thousands seed weight and harvest index. In terms of thousand seed weight, the variety Tumsa (805.80) score the highest next to Gora (896.60 g) (Table 5).

### 3.2 Farmers Variety Evaluation and Criteria

The farmers preference selection was done close to the physiological maturity after the field day was conducted. Three development agents, 8 men, and 5 women farmers evaluated the trial using plant earliness, biomass, seed size, number of branches per plant, plant height and the disease reaction are used as a criteria to select promising varieties Tumsa (23.00), Dosha (16.94) and Gora (16.83) scored up to three highest values, respectively and the lowest (8.96) was scored for the local variety (Table 5).

### 3.3 Capacity Building and Experiment Evaluation

Training on improved faba bean production was given for the farmers DAs and experts participated on demonstration trial. The main training areas were: Crop rotation considerations (the choice of what to produce and when); land preparation; tillage; plant nutrient requirements; fertilizer kinds and amounts; bio-fertilizer inoculation method, crop establishment methods; planting density, arrangement, weed, pest and disease control and harvesting methods and others were given.

**Table 4. Performance of the fababean varieties in Dedo and Bedele districts in 2018 cropping season**

| S.N | Varieties | Number of pods per plant | Number of seeds per plant | Plant height(cm) | Fresh biomass weight (kg) | Thousand seed weight (g) | Harvest index | Grain yield (g) | Rank |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Tumsa | 18.66 | 44.16 | 133.10 | 7.76 | 805.80 | 0.45 | 3430 | 3rd |
| 2 | Dosha | 24.94 | 61.55 | 142.56 | 10.60 | 731.90 | 0.42 | 4370 | 1st |
| 3 | Gora | 17.84 | 42.72 | 139.44 | 10.00 | 896.60 | 0.38 | 3800 | 2nd |
| 4 | Local | 11.21 | 28.16 | 129.38 | 5.40 | 640.50 | 0.40 | 2200 | 4th |
| Mean | | 18.16 | 44.15 | 136.12 | 8.44 | 768.70 | 0.41 | 3450.00 | |

**Table 5. Ranking farmers preference criteria of the variety selection at Dedo and Bedele in 2018**

| S.N | Varieties | Pedigree | Farmers criteria | | | | | | Rank |
|---|---|---|---|---|---|---|---|---|---|
| | | | Earliness | SS | NB | PH | DT | Total score | |
| 1 | Tumsa (EH99051-3) | EH99051-3 | 3 | 5.0 | 5.0 | 5.0 | 5.00 | 23.00 | 1st |
| 2 | Dosha (COLL 155/00-3) | COLL 155/00-3 | 5 | 2.8 | 2.8 | 3.0 | 3.34 | 16.94 | 2nd |
| 3 | Gora (EK01024-1-2) | EK01024-1-2 | 3 | 5.0 | 1.5 | 4.0 | 3.33 | 16.83 | 3rd |
| 4 | Local | Local | 2 | 1.4 | 1.5 | 2.0 | 2.00 | 8.90 | 4th |

*NB: 5=Excellent, 4=very good, 3=good, 2=Fair, 1=Poor.SS=Seed Size,NB=Number of branch per plant,PH=plant height (cm) , and DT=Disease Tolerant*
*Source: Own Result (2019)*

**Table 6. The total training during the field day one at two districts**

| | No. of participants | | | Medias |
|---|---|---|---|---|
| | M | F | Total | |
| Farmers | 212 | 110 | 322 | FBC radio, OBN TV and radio |
| Das | 12 | 4 | 16 | |
| Experts | 5 | 1 | 6 | |
| Journalist | 2 | - | 2 | |
| Researcher | 25 | 1 | 26 | |
| Total | 256 | 116 | 372 | |

*NB:DAs= Development agents, FBC=Fana broadcasting corporate,OBN=Oromia media network*

**Table 7. Costbenefit analysis for the trials**

| Items | Quantity/ Unit | Unit price/cost | Tumsa | Dosha | Gora | Local |
|---|---|---|---|---|---|---|
| Average yield (kg/hectare) | Kg | ETB | 3430 | 4370 | 3800 | 2200 |
| Adjusted yield (-10%) | -10% | | 3087 | 3933 | 3420 | 1980 |
| | In Eth | 25 ETB | 77175 | 98325 | 85500 | 49500 |
| Total gain in birr(A) | | | 77175 | 98325 | 85500 | 49500 |
| Fertilizer costs in kg | NPS | 100 Kg | 1200 | 1220 | 1200 | 1200 |
| Bio-fertilizer | Packs | 500 gm | 1000 | 1000 | 1000 | 100 |
| Seed cost | 100 kg | ETB(Dosha=42,Gora=42, Tumsa=42,Local=18) | 8400 | 8400 | 8400 | 1800 |
| Land preparation(Laborcost for land clearing, Labor cost for first plowing, Labor cost for second plowing, Labor cost for third plowing) | Ha | ETB | 1200 | 1200 | 1200 | 1200 |
| Labor costs per day | Sowing | 2 day*6person*40birr | 480 | 480 | 480 | 480 |
| | First and second weeding | 2 day*5person*40birr | 400 | 400 | 400 | 400 |
| | Fertilizer application | 1day*5 person*40birr | 200 | 200 | 200 | 200 |
| | Harvesting and threshing | 3 day*10person*40birr | 1200 | 1200 | 1200 | 1200 |
| Transporting Cost | | | 760 | 760 | 760 | 760 |
| Total costs(B) | | | 14080 | 14100 | 14080 | 6580 |
| Net Benefit(A-B) | | | 63095 | 84225 | 71420 | 42920 |

*Source: Own Result (2019)*

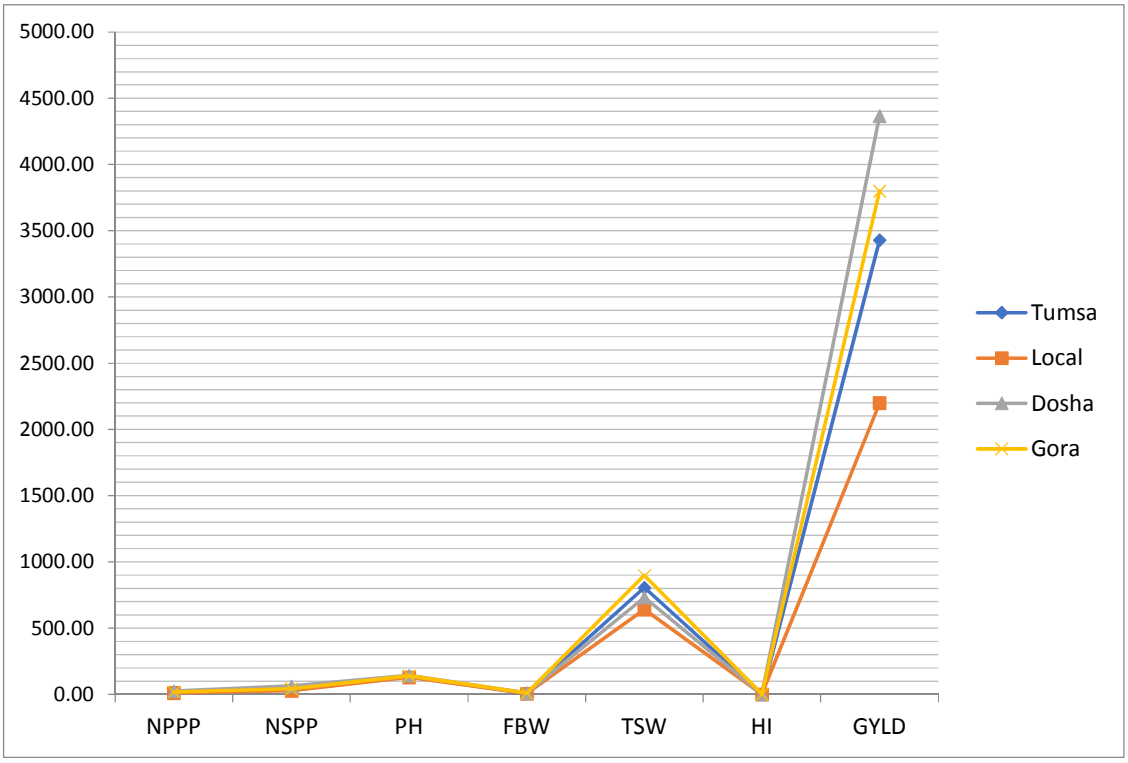


**Fig. 2. Graphical comparison of the improved and the local fababean varieties tested over location in 2018**

Field days were organized on Faba bean demonstration trial at Jimma zone Dedo woreda and Buno bedele zone Bedele woreda with consideration of different stakeholders (farmers of Digeja Urgessa, Sito and Elala kebeles, woredas and zone agricultural experts and development agents of respective Keeble's). The field day event reported by Fana Broadcasting cooperate on radio services and Oromia media network TV & radio programmes.

### 3.4 Economic Benefit Gained

From the economic point of the technology dissemination cost benefit analysis is the tools to identify the incomes incurred and the costs for obtaining the net benefits. Net benefit is calculated through reducing the gross benefit less the total costs. The net benefits that were obtained from the improved Dosha,Gora and Tumsa variety after harvesting were 84225ETB,71420 ETB and 63095 ETB respectively. But the local variety net benefit was 42920ETB. From the Table 7 it is possible to infer the improved variety Dosha, then Gora and lastly Tumsa is economically viable in the study areas than that of local varieties.

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusions

On-farm demonstration of improved of faba bean was conducted in Bedele and Dedo districts of Buno Bedele and Jimma zone respectively. From the result of the study at Dedo and Bedele districts in participation of farmers, Dosha, Gora, Tumsa and local variety fababean varieties were gives superior in grain yield respectively. The study also showed that Dosha superior in other agronomic traits except thousand seed weight and harvest index. From the farmer's preference Tumsa, Dosha, Gora and Local variety ranks up to fourth. From the agronomic and the farmer's preference the farmers less prefer local variety due to small seed size and late maturity.

### 4.2 Recommendations

- Therefore Dosha, Tumsa and Gora improved varieties with their agronomic packages selected by farmers are recommended for further scaling up and popularization in study area and similar

high land agro ecology in order to increase their faba bean production and generate more income for their livelihood.

- Further dissemination faba bean is expected from seed multipliers in producing quality seed and addressing potential area.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by Ethiopian Agricultural Research Institute and Jimma Agricultural research Center.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## APPENDIX

**A. Researcher explains about the improved**

**B. DA's visiting the trial varieties during the field day**

**Fig. 3. Researcher explains about the improved varieties during the field day**



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