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Participatory Variety Selection for Released Kabuli Type Chickpea (*Cicer arietinum* L.) Varieties in South Gondar Zone, Ethiopia

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Abstract: Participatory variety selection plays a vital role in adopting improved crop varieties into a new growing area. Farmers' preferences across locations and growing seasons must be taken into account to introduce improved varieties that farmers will accept. Evaluating improved chickpea varieties in specific agro-ecologies is a key activity to enhance the productivity of the crop. The purpose of this study was to identify adapted, high-yielding, disease-resistant, and farmers' preferred white chickpea varieties in the south Gondar zone, Ethiopia. Five Kabuli-type chickpea varieties with one local check were laid out in a randomized complete block design with three replications replicated three times during the 2019/2020 cropping season at the farmers' field of Libokemkem and Simada districts. The environment by variety interaction analysis showed a highly significant difference at high significant ($P< 0.01$) difference for genotypes implying that there is a best-fit cultivar independently for each location. The study also revealed that in some cases the researchers' selection criteria were identical to farmers' preferences. These parameters include Disease reaction, Branch number, pod size, adaptability, and early maturity. Hence, including farmers' preferences in a variety selection process is paramount important. The results revealed that among the evaluated varieties, Akuri and Habru (2116.9 kg ha^{-1}) and (2021.9ha^{-1}) produced considerably higher yields at Libokemkem and Akuri and Habru (2037.5ha^{-1}), (2025.9 kg ha^{-1}) were found as high-yielding varieties at Simada. The combined grain yield of over location also (2077kg ha^{-1}) and 2038.8ha^{-1}) for Akuri and Habru Respectively. Accordingly, the highest grain yield in the Simada district was revealed by Akuri and Habru. While at Libokemkem; Akuri and Habru demonstrated top yield scores. Therefore, Akuri and Habru varieties were well adapted to the Simada and Libokemkem districts and similar agroecological zones of the western Amhara region.

Keywords: Participatory Varietal Selection, Grain Yield, Kabuli Chickpea, Simada, Libokemkem

1. Introduction

Background and Justification

Chickpea (*Cicer arietinum* L.) is an important cool-season food legume grown and consumed predominantly in the arid and semiarid tropical regions of the world. It is the world's second most important food legume representing an important component of small-scale crop production. [24]. It is an excellent source of high-quality edible protein particularly for the underprivileged population [18]. Globally, chickpea is cultivated in an area of 17.85 million ha with an annual production [8]. Among chickpea-growing countries, India alone contributes about 70% of the world's total production [8].

Ethiopia is the leading chickpea producer in Africa, producing more than 500,000 metric tons per year from an area of 243,000 ha of smallholder farms [3]. According to the finding of food and agriculture organization [8] over 90% of grain production accounts in sub-Saharan Africa [23]. Chickpea is an economically important crop in Ethiopia grown by more than 900,000 smallholder farmers [3]. The crop is well known as one of the major food legumes having great nutritional values for millions of farming communities. Ethiopia has diverse agro-ecologies with high potential for chickpea production [10, 19] making it one of the world's leading countries in terms of productivity per unit area [7].

Chickpea seeds are eaten fresh as green vegetables, parched, fried, roasted, and boiled and it is valued for their nutritive seeds with high protein content, 25.3-28.9%, after dehulling [15]. Chickpea seed has 38- 59% carbohydrate, 3% fiber, 4.8-5.5% oil, 3% ash, 0.2% calcium, and 0.3% phosphorus In Ethiopia, smallholder farmers grow chickpeas at the end of the main rainy season using residual soil moisture because of its ability to withstand drought stress. Through efficient use of the residual moisture, chickpea also allows farmers to harvest two crops in a growing season (cereal followed by chickpea), improving their food supply, a secure an additional source of income. Despite its importance, the national (19.13 qt/ha) as well as regional average yields (16.58 qt/ha) of chickpeas are low due to various production constraints including low yield potential of landraces, lack of superior varieties, their susceptibility to biotic and abiotic stresses and poor cultural practices are some the serious ''constraints in chickpea production in Ethiopia'' reported on adoption studies on improved Chickpea varieties and in Ethiopia and Chickpea and nature, composition, and utilization of grain legumes [4, 1, 15]. Chickpea varieties were released by the various national and regional research centers of the country. Farmers have no ample information about the released varieties because they were released with poor involvement of farmers and the released varieties had not yet been tested in the study area. In the country, efforts have been made through PVS to develop and popularize improved varieties of some crops.

A participatory approach is being carried out in many crops like bread wheat reported that farmer's preferences vary with environmental conditions, traits of interest, ease of cultural practice, processing, use and marketability of the product, ceremonial and religious values [5, 6, 22]. However, the farmers' selection criteria for improved chickpea varieties were not assessed and well documented, especially in the South Gondar zone Simada and Libokemkem districts. Therefore, the objectives of this study were to evaluate the performance of the released kabuli-type chickpea varieties through PVS and to assess farmers' selection criteria for future chickpea improvement work with the participation of farmers in the South Gondar administration zone in Simada and Libokemkem districts.

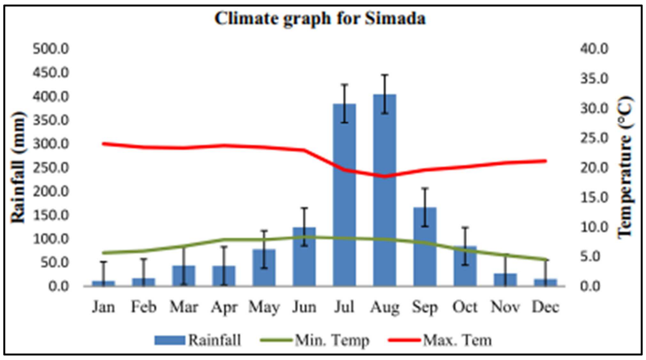
2. Materials and Methods

2.1. Description of the Experimental Site

The trial was conducted in Libokemkem and Simada districts in the South Gondar Zone of the Amhara Region of Ethiopia during the 2019/2020 main cropping season. The two locations are 167 km apart and are among the promising chickpeas growing areas in the zone. Simada is located at 11 29°59.99°N latitude and 38 140 60.0000 E longitude (https://latitude.to/article s-by country/et/Ethiopia/229186/Simada) with elevations ranging from 1196 to 3525 m above sea level and divided into three climatic zones: middle altitude (40 %), highland (10 %), and lowland (50 %) [21]. Annual rainfall for Simada ranges from 1000 to 1500 mm and seasonal climatic detail of the site in the year of the experiment is presented in Figure 1.

The soil types of Simada are red, brown, black, and grey, which account for about 30%, 30%, 25%, and 15% of the total area, respectively, with red and brown soils being the most common [20]. According to the World Reference Base for Soil Resources, 2014 (update, 2015). The soil type of Simada is classified into Lithic Leptosol (50%), Eutric eptosol (30 %), and Eutric Cambisol (20 %) which using the location's latitudinal and longitudinal coordinate values. The major crops grown in Simada include cereals and pulses, such as beans [9, 16].

Libokemkem is found between 12 190 60.0000 N latitude and 37 390 59.9900 E longitude (https://latitude.to/articles-by-country) /et/Ethiopia/305357/Libokemkem) with an altitude ranging from 1800 to 2850 m above sea level [2]. The rainfall ranged from 73-372 mm from May to October of the growing season and annual rainfall and temperature distribution for the growing season is presented in Figure 1. The soil type of Libokemkem is 60 % clay loam, 14 % silt loam and 26 % clay soil [17]. Farmers in the district grow local bean varieties for double cropping, where chickpea is planted after beans are harvested to take advantage of the soil moisture reservoir.



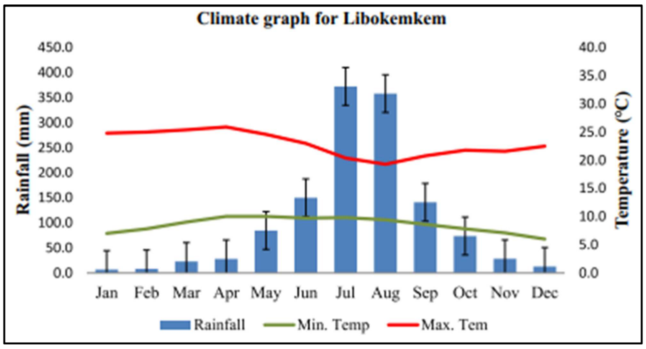


Figure 1. *Seasonal climatic detail of the site in the year of the experiment.*

2.2. Treatments and Experimental Design

A randomized complete block design with three replications was used to conduct the experiments. The trials included five released chickpea varieties, Arerti (FLIP 82-

150C), Habru (FLIP 83-13C), Yelibe (ICCV-14808), Akuri (ICC-03402), Kasech (FLIP 95-31C) and Local check. Land preparation was done following conventional practices to make the field suitable for planting. Each variety was planted in six rows of 4m* 1.8m =7.2 m^2. The net plots were 4.8 m^2 lengths per plot. The inter-row and intra-row spacing were maintained at 40 cm and 10cm, respectively. The crop was planted in mid to late August. Fertilizer was applied to all plots in the form of NPS at the recommended rate of 100kgha^{-1} at planting.

2.3. Data Collection and Analysis

Data were collected on the number of days to flowering and maturity, pods per plant, plant height, hundred seed weight, and grain yield. At physiological maturity, ten plants were sampled randomly from each plot leaving two border rows on both sides. The height of each sampled plant was measured and pods were counted. The number of seeds per pod was determined from 20 pods randomly selected from the sample plants and then taken seeds were divided by the total number of pods to get an average number of seeds per pod.

The final plant stand of the four central rows per plot was counted leaving 0.5m on both sides of each row. The pods were removed, sun-dried, and threshed by hand. The grain was further dried and weighed with a sensitive balance. The moisture content was determined with a portable moisture tester and adjusted to 10% stand moisture content. Hundred seed weight was measured from randomly counted 100 seeds per plot in three replicates. Ten plants per plot were randomly selected and cut at the collar. Forty farmers (25 male and 15 females) ranked varieties using the farmers' selection criteria of plant height, pods per plant, disease resistance, seed size, and yield with a score from 1 to 6 (1 = excellent, 2 = very good, 3 = good, 4 = average, 5 = poor and 6 = very poor). The data collected were subjected to Analysis of Variance (ANOVA) by using R.4.0.3 software to assess the significant difference between the varieties. Mean separation was carried out using the Least Significance Difference test (LSD) at 5% and 1% probability levels.

3. Results and Discussions

The Participatory Variety Selection (PVS) ensured farmers were a participant in the selection of improved chickpea crop varieties in comparison with a local check based on their preference criteria. Combined analyses of data from the two trial sites (Libokemkem and Simada districts) most of the parameters showed very highly significant varietal differences ($P<0.01$) (Table 1). Mean squares from combined analysis of variance for yield and other traits of Kabuli chickpea evaluated over two locations in the 2019 Cropping Season varieties, locations, and errors.

The location revealed highly significant variations in parameters like days to flowering, plant height, seed per pod, grain yield, and hundred seed weight. Concerning the variety, most of the parameters show statistically significant stand count at germination and harvesting, days of flowering and maturity, plant height, number of pods per plant, grain yield and hundred seed weight except stand count at harvesting. This indicates that all the varieties responded not similar to the tested locations (Table 1).

3.1. Phenological and Growth Parameters

Days to flowering ranged from Akuri (66.33) to Local check (79.83 days) Kabuli chickpea varieties in both locations. The day's differences in flowering between earlier and late flowered varieties vary from 13.5 days. (Table 2). The longest days to flowering were recorded at the variety of local check (81.33) and local check (116.33) at Simada and Libokemkem districts respectively. Whereas the shortest days to flowering were 68.67 from the variety of Akuri and 64 at Simada and Libokemkem Districts respectively. Days to maturity ranged from 106.33 - 113.67 from a variety of (Kasech and local checks) respectively. The longest days to maturity was recorded at the variety of Ararti (114) and local check (116.6) at Simada and Libokemkem districts respectively. Whereas the shortest days to maturity and Yelibe 105.66 at Simada and the variety of Ylibe (106.66) and Kasech (105.66) at Libokemkem Districts respectively. Similarly, plant height ranged from Yelibie (42.1) to Habru (48.02 cm) at the two testing sites. These findings are in line with as… has been shown and discussed [14] who reported considerable variation in the days to flowering, days to maturity, and plant height of different chickpea varieties when planted under various environments. This result harmony with [26] significant differences among the varieties in plant height.

3.2. Yield and Yield Components

Analysis of variance across two locations showed that number of pods per plant, number of seeds per pod and grain yield and hundred seed weight showed highly significant ($P < 0.01$) differences among the varieties (Table 1). Local checks had the highest average number of pods per plant (76.5 pods) while Kasech obtained the lowest number of pods per plant (43.33) over two locations. While the highest average number of seeds per pod was recorded from a local check (2.00). The lowest number of seeds per pod was recorded from varieties of Arerti (1.2) over two locations.

The maximum hundred seed weights (37.17g) and (37g) were recorded in a variety of Habru and Kasech respectively. Whereas, the smallest hundred seed weight (14.67g) was recorded in the local check at two locations (Table 2).

The average grain yield of the chickpea varieties over two locations ranged from 2077 -744.07 kg ha^{-1} for Akuri and the Local Check respectively. The results revealed that among the evaluated varieties, Akuri and Habru (2116.9 kg ha^{-1}) and (2021.9ha^{-1}) produced considerably higher yields at Libokemkem Similarly, Akuri and Habru (2037.5ha^{-1}), (2025.9 kg ha^{-1}) were found as high-yielding varieties at Simada. The combined grain yield of over location also (2077kg ha^{-1}) and 2038.8ha^{-1}) for Akuri and Habru respectively.

The yield differences indicate the possibility of obtaining high-yielding varieties with proper selection in the fields. The promising varieties Habru and Akuri produced 2038.8 kg ha^{-1} and 2077 kg ha^{-1} of grain yields with superiority over the other varieties. This Agreement in line with findings, reported considerable variation among chickpea varieties indicating that grain yield inherent potential of chickpeas varied from variety to variety and over locations [1, 13, 14].

Table 1. *Mean squares from combined analysis of variance for yield and other traits of Kabuli chickpea evaluated over two locations in the 2019 Cropping Season.*

SOV	SG	SH	DF	DM	PH	NPP	SPP	GY	HSW
Varieties	543.18**	216.26^{ns}	115.1**	40.39***	24.00**	645.48***	0.49^{ns}	1406366**	314.45**
Location	121^{ns}	128.44^{ns}	140.03***	1.00^{ns}	3.36*	215.11^{ns}	181.35**	191789*	0.52^{ns}
Var: Loc	49.68^{ns}	123.76^{ns}	0.69ns	10.28^{ns}	1.04^{ns}	0.0004^{ns}	0.23^{ns}	44299^{ns}	2.38^{ns}
Loc: Rep	95.19	51.36^{ns}	0.56ns	0.41^{ns}	1.82ns	186.03^{ns}	0.35^{ns}	9125^{ns}	14.1ns
Error	39.17	123.44	0.41	0.96	0.69	101.2	0.27	28309	314.45**

Where, **=highly significant at P ≤ 0.01; *=Significant at P ≤ 0.05; ns=Not significant at P=0.05; SOV=source of variation, SG= stand count at germination, stand count at harvest, DF= days to flowering, DM=Days to maturity; PH=Plant height; N PP=number of Pod per plant, SPP=number of seeds per pod; GY=Grain yield (kg/ha)

Table 2. *Mean separation from combined analysis of variance for yield and other traits of Kabuli chickpea evaluated over two locations in the 2019 Cropping Season.*

Var	SG	SH	DF	DM	PH	PP	SPP	GY	HSW
Kasech	65.33c	51.33b	71.67c	106.33d	45.43b	43.33c	1.43a	1111.35d	37.00a
Yelebie	77.5b	76.00a	69.00d	107.5c	42.1c	51.5bc	1.23a	1688.8b	33.17b
Akuri	68.17bc	55.67b	66.33e	109.67b	44.8b	62.17b	1.2a	2077a	36.83a
Ararti	69.67bc	55.17b	72.83b	112.67a	42.98c	54.00bc	1.2a	1343.69bc	32.17b
Habru	69.83bc	64.5ab	68.5d	110.17b	48.02a	54.17c	1.47a	2038.8a	37.17a
Local	93.67a	55.67b	79.83a	113.67a	45.3b	76.5a	2.00a	744.07e	14.67c
GM	74	57.94	71.36	110	44.77	56.94	3.42	1500	31.83
CV	8.45	19.17	0.89	0.89	1.84	17.66	15.18	11.21	4.26
LSD	4.38	7.78	0.44	0.68	0.58	7.00	0.36	117.82	0.95

*Means with the same letter are not significantly different; GM=grand mean, CV=coefficient of variation, LSD= least significant difference, SG=Stand count at germination, SH=Stand count at harvest, PH=plant height, DF= days to flowering, DM=days to maturity, PPP= number of pods per plant, SPP= number of seeds per pod, HSW=hundred seed weight, GY=grain yield at Simada and Libokemkem district

Table 3. *Mean separation from a separate analysis of variance for yield and other traits of Kabuli chickpea evaluated at Simada in the 2019 Cropping Season.*

Var	SG	SH	DF	DM	PH	PPP	SPP	GY	HSW
Kasech	67.67d	54.00bc	73.33b	107d	45.87b	45.67c	1.2a	1074.3c	38.00a
Yelebie	80.00b	67.67ab	71.33c	108.33cd	42.00c	54.00bc	1.2a	1500.7a	34.67a
Akuri	73.00c	60.67abc	68.67d	110bc	45.13b	64.67ab	1.07a	2037.5a	38.33a
Ararti	72.33c	56.67abc	74.67b	114a	43.37c	56.33bc	1.07a	1152.8b	33.33b
Habru	72.67c	71.67a	70.67c	110.67b	48.17a	56.67bc	1.27a	2025.5a	38.67a
Local	89.33a	48.33c	81.33a	111b	45.93b	79.00a	1.33a	775c	15.67c
GM	75.83	59.83	73.33	110.16	45.07	59.38	1.17	1427.66	33.11
CV	3.57	14.15	1.19	1.08	1.69	16.31	17.71	16.07	4.04
R2	0.93	0.63	0.97	0.86	0.93	0.71	0.31	0.89	0.98

*Means with the same letter are not significantly different; *Means with the same letter are not significantly different; GM=grand mean, CV=coefficient of variation, LSD= least significant difference, SG=Stand count at germination, SH=Stand count at harvest, PH=plant height, DF= days to flowering, DM=days to maturity, PPP= number of pods per plant, SPP= number of seeds per pod, HSW=hundred seed weight, GY=grain yield

Table 4. *Mean separation from a separate analysis of variance for yield and other traits of Kabuli chickpea evaluated at Libokemkem in the 2019 Cropping Season.*

Var	SG	SH	DF	DM	PH	PPP	SPP	GY	HSW
Kasech	63.33b	48.67a	70.00b	105.66d	45.00b	41.00c	5.66ab	1148.4e	36.00a
Yelebie	74.66b	63.00a	66.66c	106.66d	42.2c	49.00bc	5.33b	1876.9c	31.67b
Akuri	63.33b	50.67a	64.00d	109.33c	44.45bc	59.67ab	5.33b	2116.9a	35.33a
Ararti	67.b	53.67a	71.00b	111.33b	42.6bc	51.67bc	5.33b	1534.6d	31.00b
Habru	67.b	57.33a	66.33c	109.66c	47.86a	51.67bc	5.67ab	2051.9b	35.67a
Local	98.00a	63.00a	78.33a	116.33a	44.66b	74.00a	6.66a	713.15f	13.67c
GM	72.16	56.05	69.38	109.83	44.46	54.5	5.67	1573.64	30.55
CV	11.09	24,43	1.48	0.55	2.96	17.63	12.05	0.63	4.37
R2	0.82	0.24	0.97	0.98	0.81	0.71	0.53	0.99	0.98

*Means with the same letter are not significantly different; SG= Stand at germination; SH = Stand at harvest DF = Days to flowering; DM=Days to maturity; PH=Plant height; PP=Pod per plant; SSP=Seed per pod; GY=Grain yield; HSW= hundred seed weight.

Table 5. *Result of the rank of Kabuli type chickpea varieties by farmer's selection at Simada and Libokemkem district, 2019 cropping season.*

Criteria	Kasech	Yelibie	Akuri	Ararti	Habru	Local
Simada district						
Branch number	26	24	28	24	29	16
Disease reaction	22	26	28	22	29	10
Highly Pods no set	24	27	27	24	30	28
Adaptability	26	27	25	26	29	22
Early maturity	29	26	26	27	28	23
Total	127	130	134	123	145	99
Rank	4	3	2	5	1	6
Libokemkem district						
Branch number	24	24	29	25	28	20
Disease reaction	22	25	28	22	28	13
Pod number	22	27	29	24	29	28
Adaptability	21	27	29	22	27	24
Early maturity	26	25	26	26	27	23
Total	115	128	141	119	139	108
Rank	5	3	1	4	2	6

3.3. Participatory Varietal Selection, Preference, and Ranking of Varieties

Forty farmers (25 male and 15 female) ranked varieties using the farmers' selection criteria Adaptability, pod number, early maturity, branch number and disease reaction were selection criteria set by farmers for ranking and selection of the best-fit chickpea varieties (Table 5). With the score from 1 to 6 (1 = excellent, 2 = very good, 3 = good, 4 = average, 5 = poor and 6 = very poor).

Libokemkem farmers' preferred varieties are Akuri, Habru, Yelibe, Arerti, Kasech and Local check respectively. In the same token, the yield was recorded at 2116.9. 2051.9, 1876.9, 1534.6, 1148.4 and 713.15 kg ha^{-1} in Libokemkem district as 1st, 2nd, 3rd, 4th, 5th and 6th respectively. Similarly, Simada district farmers preferred varieties are Akuri, Harbu, Yelibe, Kasech, and Arerti and local checks were recorded in 2037.5, 2025.5, 1500.7, 1074.3, 1152.8 and 775 kg ha^{-1} respectively. Because of that, chickpea varieties such as Habru, Akuri, Yelibe, Kasech, Arerti and local check were as 1st, 2nd, 3rd, 4th, 5th and 6th respectively in Simada district (Table 5). Overall assessment results Libokemkem district showed that chickpea varieties Arerti, Habru and Yelibe were preferred as 1st, 2nd and 3rd, respectively and results in Simada district Habru, Akuri and Yelbie were preferred as 1st, 2nd and 3rd, respectively. Whereas Yelbie was 3rd in both districts.

3.4. Training

the training program was prepared to improve the concentration of farmers on chickpea varieties available technology in which 40 farmers (25 males, 15 females) at Simada and Libokemkem districts), and 8 extension personnel (7 males, 1 female) also participated in the 48 individuals involved in chickpea training. An information package or manual was prepared on improved chickpea technologies in Simada and Libokemkem districts for development agents.

4. Conclusion and Recommendation

Participatory Varietal Selection (PVS) on chickpeas indicated variability of improved varieties preferences among farmers as well as from district to district. Farmers may require multiple traits from one key crop such as chickpea. However, researchers may not know the traits that are important to farmers and vice versa. Continuous evaluation of diverse chickpea varieties to substitute local varieties might accelerate the adoption of improved varieties and at the same time maintain the genetic diversity of the chickpea.

Chickpea varieties, Akuri and Habru demonstrated superiority in grain yield and hundred seed weight over the local check, and they are best adapted to the test locations. The best-performing chickpea varieties, Akuri and Habru produced high, stable and consistent yields across locations and fulfilled all other farmers' requirements. Therefore, based on yielding performance and farmers' preference, varieties Akuri and Habru are recommended for production in the selected districts and similar agroecological zones in Northwestern Amhara region Ethiopia.

Conflict of Interest

There is no conflict of interest.

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