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Participatory Varietal Evaluation and Selection of High-yielding Desi Chickpea (*Cicer arietinum* L.) Varieties in the Central Zone of Tigray, Northern Ethiopia

Kiros Wolday [a*]

[a] *Department of Crop Sciences, Axum Agricultural Research Center, Tigray Agricultural Research Institute, Axum, P.O. Box:230, Ethiopia.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Background and Justification: Since farmers/users preferred different types in different localities, not all of the released, high-yielding varieties were adopted equally by users. This is due to the fact that the varieties were generated using traditional/ conventional breeding methods without taking users preference into account. Therefore, participatory varietal evaluation and selection (PVS) approach is the best method to increase efficiency and effectiveness of technology(variety) adoption rates. This is because the PVS research study is carried out at the target (real) condition.
Objective: To evaluate and select high yielding, best adapted and farmers preferred chickpea variety/ies.

**Corresponding author: E-mail: kiroswolday@gmail.com;*

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Material and Methods: Grandmother trial was conducted in a randomized complete block design with four replications. Moreover, mother trial was done on four farmers aimed for the ranking of varieties by farmers. Data were collected on important yield and yield components. Besides, Atotal of 100 farmers in the two districts evaluated and ranked the varieties based on their own selection criteria.

Results: Analysis of variance revealed significant difference among varieties for their yield and yield components. Dimtu and Teketay in Tahtay Maichew; Dimtu and Dalota in Laelay Maichew were found early maturing varieties. Dimtu, Dalota and Teketay had bigger seed size. Higher grain yield were obtained from Dimtu (2462.5 kg ha^{-1}), in Tahtay Maichew and Teketay (2804.6 kg ha^{-1}) in Laelay Maichew respectively. Similarly the cummulative percent selection result revealed farmers selected Dimtu (97.83%) in Tahtay Maichew and Teketay (87%) in Laelay Maichew respectively.

Conclusion: Dimtu in Tahtay Maichew (district) and Teketay in Laelay Maichew (district) that performed better in grain yield and attracted farmers preference could be applied in the study areas and in similar agro ecologies to improve chickpea production and productivity.

Keywords: Chickpea; grain yield; matrix ranking; mother trials; participatory; varietal selection.

1. INTRODUCTION

Chickpea isself-pollinated crop (Its natural out crossing ranges from 0-1%) having adiploid chromosome number (2n=16) [1] and it is categorized under thefamily Fabaceae. It is the only cultivated species of the genius *cicer*.

It ranks third most significant cool season food legume (CSFL) in the world next to soybeans and haricot beans [2].18.01 million tons of it were produced worldwide on 14.01 million ton/ha of cultivation and the average productivity was 1.22 Million $tonha^{-1}$. The top ten chickpea producers were:India, Australia,Turkey, Ethiopia, RussianFederation,Mayanmar,Pakistan,Mexico,Ir anand USA [2].

In Ethiopia, chickpea is widely grown across the country and serves as a multi-purpose crop. It is Produced in different regions of the country, mainly in Amhara, Oromia, Tigray and Sothern Nation, nationalities and peoples (SNNP) [3]. Although Ethiopia is considered as center of diversity for chickpea; the wild relative (*Cicer cuneatum*) of cultivated chickpea is found in Tigray region [4].

It is a multipurpose crop that is planted extensively throughout the nation [3]. In the first place, it fixes atmospheric nitrogen in soils, increasing soil fertility and reducing the need for fertilizer in ensuing crops. Second, because the crop may be cultivated as a second crop utilizing residual moisture, it promotes a more intensive and productive use of land, especially in locations where land is limited. According to Gil et al. [5] chickpeas provide a reasonably priced source of protein (20–23% in the grain), energy (carbohydrates, 40%), and oil (3–6%). This suggests that by include chickpeas in a person's regular diet, malnutrition may be decreased and human health could be improved, particularly for the underprivileged who cannot buy cattle products.

Despite the critical relevance of chickpea, the average productivity in the Tigray region is just 1.63 t ha^{-1}, much below the crop's potential due to several causes and less than the national average yield of 2.58 t ha^{-1} [6]. The main factors limiting chickpea production are low yielding of the native variety, lack of access to improved varieties, biotic and abiotic restrictions [7,8]. The cultivation of chickpea is exclusively reliant on the soil's residual moisture content, as planting occurs when the main rainy season ends and the area is free of water logging. It seems that the stages of chickpea flowering and pod setting are the most vulnerable to water stress [9].

Despite the fact that national research centers have published several better chickpea cultivars. The adaptation and yield performance of these cultivars in the northern Ethiopian region of Tigray, however, have not been assessed. Furthermore, farmers are typically only involved in the last phases of variety testing, which is usually after tested varieties have been approved for release. Regarding the administration of these trials and the types studied, farmers frequently have little or no say. Participatory varietal evaluation and selection, according to Ceccarelli et al. [10] is a straightforward method by which breeders and agronomists discover which genotypes are favored by farmers and perform well on farms.Therefore, using the

participatory varietal selection (PVS) approach, a study was carried out to examine the effectiveness of various chickpea varieties in the farmer's field with the following specific objectives: (i) to determine which chickpea varieties are more productive and agronomic in the target environment; (ii) to select the varieties that farmers prefer.

2. MATERIALS AND METHODS

2.1 Description of the Study Sites

During the 2019/2020 main cropping season, participatory varietal selection (PVS) for desi type chickpea was conducted in the districts of Tahtay Maichew (Kewanit site), Laelay Maichew (Hatsebo site), in central Zone of Tigray, Northern Ethiopia.

The PVS testing site (Hatsebo) is located at 14°6'46"N and 38°46'3"E at 2084 meters above sea level(m.a.s. l). The monthly mean minimum and maximum temperature of Hatsebo kebelle ranges from 10 °c to 29 °c. wheras, Kewanit is situated at 14º06'3"N and 038º37'7"E, 2140 m.a.s.l. and mean monthly minimum and maximum Tº of the site are 12.6 °c and 25.5 °c respectively.

The study areas (Hatsebo and kewanit) are located in northern semi-arid tropical zone, which is mostly known for its faba bean, wheat, chickpea, and teff cultivation. Both environmentally and economically, chickpea is a significant crop in the region. The study areas (Hatsebo and Kewanit), receive typical rainy season ranges from 400 mm–800 mm of annual precipitation, the amostly from July to September but cocentrated on July and Augst. Both locations have vertisol or soil dominated by clay particles. Chickpea is mostly grown with a residual moisture in the study areas.

2.2 Experimental Design and Treatments

At the farmer's fields, four released desi chickpea types including the local check variety were put to the test. Three varieties: Teketay, Dalota, and Dimtu released by Debrezeit agricultural research center and one variety (Mastewal) released by DebreBirhan agricultural research center and a local check described to determine their zones of adaption are presented in Table 1.

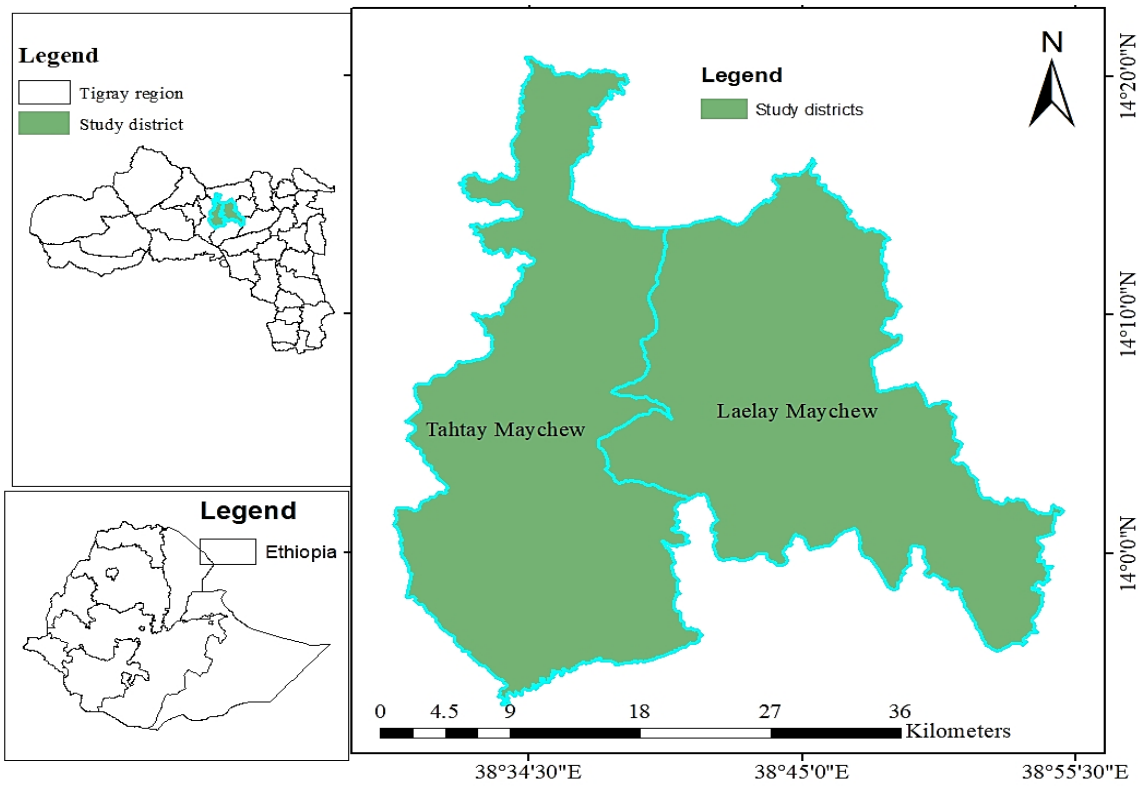

Fig. 1. Map of the study districts (Tahtay maychew and Laelay Maychew)

Table 1. Description of chickpea varieties

S/no.	Varieties	Type	Source	Year of release	Adaptation Zone	
					Altitude(m)	Rainfall(mm)
1	Dalota	Desi	DZARC	2013	1800-2700	700-1200
2	Dimtu	Desi	DZARC	2016	1800-2800	700-1200
3	Teketay	Desi	DZARC	2013	1800-2600	700-1200
4	Mastewal	Desi	DBARC	2006	2000-2600	900-1000
5	Local check	Desi	Local	_	1800-2200	400-800

Source: Ethiopian Crop Variety Register; (2022)
Notes; AxARC: Axum Agricultural Research Center;
DZARC: Debrezeit Agricultural Research Center; DBARC: Debrebrhan Agricultural Research Center

The experiment was done with five model farmers, one grandmother trial conducted in a randomized complete block design (RCBD) with 4 replications and four mother trials used for farmers'evaluation and selection of their preferred varieties. A5m x 5m ($25m^2$) plot area was used for each variety. Seventeen rows of 5m length with 1m between plots, 0.3m between row, and 0.1m between plants, respectively, was used for each variety for the mother trial. A distance between replications, plots and plants was 1.5m, 1m and 0.1m respectively in the grand mother trial. Blended fertilizers: NPSB and NPSZnB at 121 kg ha^{-1} in Laelay Maichew(Hatsebo) and Tahtay Maichew (Kewanit) were applied at sowing time respectively.The recommended fertilizers were drilled at the center of the rows and covered with soil inorder not to contact with the seeds. Seeds were sown by hand drilling two seeds per spot. Two weeks after emergence plants were maintained to 50 plants per row and a total of 850 plants per plot.

Besides, participatory variety evaluation was carried out with Focus Group Discussion at maturity of the crop. During the evaluation 15 women and 39 men participated in Laelay Maichew. While ten (10) women and 36 men farmers have participated in Tahtay Maichew. The selection criterias used by the farmers' were disease resistance(Fusarium wilt/major disease and Acochyta blight/as minor disease) , earliness, number of pods $plant^{-1}$, seed size, and grain yield.

Accordingly, varieties were evaluated for their yield components and adaptability criterias, where five(5)scale ratings were used inboth locations (1 = very good, 2= good, 3=fair 4= poor and 5= very poor) in adaptability. Finally farmer's preferences on the varieties were compared with quantitative (researcher) data and the varieties that showed best match were selected for further demonstration.

2.3 Data Collection

Days to 50% flowering (DTF): when at least one open flower was observed on about 50% of the plants in the plot .and90**%** maturity (DTM) was recorded for all the varieties when 90% of the plot was ready for harvesting i.e., foliage color becomes yellowish, lower pods starting shedding pods and seeds harden. At harvesting time, random sample of six (6) tagged plants were taken from each plot in the four replications (grandmother trial) were used to determine plant height (PHT) and number of pods per plant (NPP). Harvesting was done from the central 15 rows (2 rows left to remove the border effect). The biomass was sun dried for a week. Threshing was done manually after sun drying to separate the straw and grain yield (GY). To maintain uniformity, the final grain yield of each plot was adjusted to 12% seed moisture content. Then after, grain yield was weighed using electronic balance. Yield obtained from plot was converted to Kg ha^{-1}. Finally, weight of hundred seeds was taken to assess difference in seed size among the varieties.

Variety selection and evaluation at maturity was based on adaptability and seed quality preferences (by removing seed of plants from the boarder rows for seed size comparison) and yield performance. The crop adaptability characteristics included, earliness to maturity, number of pods per plant, seed size and grain yield.

2.4 Statistical Analysis

Plots of the distribution of the residuals, a normal and half-normal plots and a plot of the residuals against the fitted values were produced to assess whether the normality and homogeinity of variance assumptions of the data was violated. Therefore, analysis was carried out separately for each location.

Data collected from the grandmother trial were subjected to the analysis of variance (ANOVA)

appropriate to randomized complete block design using the SAS software, version 9.1 [11]. The least significant difference (LSD) test at 5% probability was used for the comparison of means values. In addition to this data recorded on the mother trialswere analyzed. Microsoft Excel was used for the descriptive analysis of the preference rankings.

3. RESULTS AND DISCUSSION

3.1 Agronomic Performance of the Grandmother Trial in the Two Locatios in 2019/2020

Major agronomic characters i.e., 50% days to flowering, 90% days to maturity, plant height(cm), number of pods per plant (NPPL), grain yield and hundred seed weight (HSW) are presented in Table 2 and Table 3 separetly and respectively in each location . The results of the ANOVA (analysis of variance) indicated that there were statistical differences in the yield and yield components of chickpea varieties in both districts. the significant differences among the varietie indicated that the presence of genetic variation among the tested desi chickpea varieties for their yield and yield components. Amare and kassahun [12]; Daniel et al. [13] and Gebre-Egziabher et al. [14] hve shown significant variation among commen bean varieties most of the yield and yield rlated traits.

Significantly the shortest days to flowering and maturity was recoreded from Teketay and Dimtu compared to the local check in Tahtay Maichew. where as the longest days to flowering and maturity in this location were recorded from the local check (control) and the variety Mastewal. Dimtu and Dalot as ignificantly took shorter days to maturity ($P < 0.05$) from the other varieties. in Laelay Maichew (Table 3). The reason could be due to the genetic by environment inteaction. Similar result and conclusion reported by Funga et al. [15]. Similar result and conclusion was reached by Mulalem et al. [16] who stated that faba bean genotypes differed for days to floweing and maturity in the grand mother trial.

Varieties were also significantly different for plant height in Tahtay Maichew, where the tallest plant was recorded on the local variety (47.25 cm) while variety Mastewal had the short plant height (37.95 cm) (Table 1). However, no significant differences were observed between the different varieties in Laelay Maichew (Table 2). This could be due to genetic variation among the different Chickpea varieties tested. Similar significant difference among faba bean genotypes was observed for days to maturity in Tahtay Maichew district [17].

The analysis of variance results revealed that varieties were significantly different in the number of pods per plant in Tahtay Maichew and Laelay Maichew (Tables 2 and 3). No significant difference was observed among local check, Dimtu and Dalota for number of pods per plant. Significantly highest number of pods per plant was counted the local variety (57.56) Dimtu (48.44) and Teketay (47) respectively compared to Mastewal in Tahtay Maichew district.

In Laelay Maichew(Hatsebo), local check and Teketay (varieties) significantly differed from Dimtu, Dalota and Mastewal in the number of pods per plant. The highest number of pods per plant was recorded from Local check (56.88) followed by Teketay (50.54). Although the highest number of pods per plant was recorded from the local variety in both the localities, hundred seed weight was lower than those of the varieties evaluated. The heavier hundred seed weight was obtained from Dimtu followed by Dalota in both sites.

Table 2. Mean Agronomic performance of chickpea varieties in the grandmother trial, 2019/2020 in Tahtay Maichew, 2019/2020

Varieties	DTF	DTM	PHT(cm)	NPPL	GY(kg/ha)	HSW(g)
Teketay	42.25^{b}	103.5^{b}	39.35^{ab}	47.05^{ab}	2172.9^{a}	28.23^{b}
Dimtu	43.75^{ab}	102.75^{b}	40.18^{ab}	48.44^{ab}	2462.5^{a}	33.98^{a}
Dalota	42.25^{b}	106.25^{ab}	42.55^{ab}	45.25^{ab}	2155^{a}	32.50^{a}
Mastewal	45.5^{a}	107.25^{ab}	37.95^{b}	37.366^{b}	2120^{a}	26.55^{b}
Local	45^{a}	108.5^{a}	47.25^{a}	57.56^{a}	1430^{b}	14.1^{c}
LSD (5%)	2.53	4.8577	8.5233	12.64	460.92	1.9736
CV (%)	3.75	2.98	13.34	17.44	14.47	4.73

DTF: Days to flowering; DTM: Days to Maturity, PHT: Plant height (cm), NPPL: Number of pods per plant; GY: Grain yield;HSW= Hundred seed weight.Means followed by the same letter(s) with in a column are not significantly different atP= 0.05

Table 3. Mean yield and yield components of desi -chickpea varieties in the grandmother trial in Laelay Maichew (Hatsebo), 2019/2020

Varieties	50% DF	90% DM	PHT(cm)	NPPL	GY(Kg/ha)	HSW(g)
Teketay	39.75^{b}	92.75^{a}	36.15	50.54^{a}	2804.6^{a}	28.33^{b}
Dimtu	35.25^{c}	88.25^{b}	35.35	38.58^{b}	2523.8^{ab}	32.13^{a}
Dalota	39.25^{b}	89.5^{b}	34.95	40.13^{b}	2629.1^{a}	30.53^{a}
Mastewal	44.5^{a}	92.75^{a}	34.2	39.98^{b}	2007.1^{bc}	25.88^{c}
Local	45.25^{a}	94.5^{a}	36.65	56.88^{a}	1436^{c}	13.35^{d}
LSD (5%)	2.5	2.61	Ns	8.44	612.05	1.83
CV (%)	3.98	1.85	5.65	12.11	17.27	4.42

DTF: Days to flowering; DTM: Days to Maturity, PHT: Plant height (cm), NPPL: Number of pods per plant; GY: Grain yield;HSW= Hundred seed weight. Means followed by the same letter(s) with in a column are not significantly different at P= 0.05

Analyses of Variance (ANOVA) result showed that all varieties had significantly higher grain yield over the local variety in Tahtay Maichewat 0.05 probability level (Table 2**)**. The highest grain yield was obtained from Dimtu (2465 kg ha^{-1}), Teketay (2172 kg ha^{-1}) and Dalota (2155 kg ha^{-1}), respectively in Tahtay Maichew. Grain yield also showed significant variation among varieties at Laelay Maichew. The local variety gave significantly lower grain yield. The highest grain yield were obtained from Teketay(2804.6 kg ha^{-1}), Dalota (2629.1 kg ha^{-1}) and Dimtu (2523.8 kg ha^{-1}). This could be due to the combine effects of number of pods per plant (NPPL) and bigger seed size in both locations when compared to the local variety with the smallest seed size. Similarly a participatory selection and evaluation (PVS) of chickpea varieties conducted in Northen Ethiopia also reported the highest grain yield was achieved in Teketay.The result also agrees with the findigs of Goa and Gezahagn [18] who reported that significantly the highest grain yield was recored in Teketay in Konta and Tocha Districts in Southern Ethiopia. On the other hand a genotype by envoronment inreraction result carried out by Debre zeit agricultural research center showed that higher grain yield was obtained from variety Dimtu and released to increase chickpea productivity and productivity [15].

3.2 Farmers Raking of Varieties Based on Their Preferene

Varieties Dimtu, Dalota and Teketaywere selected by 23.91%, 21.71% and 20.37% of the farmers respectively for their short cycle in Tahtay Maichew (Table 4). Considering number of pods per plant farmers selected for local varity, Dimtu andTeketayas their 1st , 2nd and3rd preference respectively.On the other hand, most of the farmers selected Dimtu, Dalota,Teketay and local check in decreasing order of preference with respect to seed size.

In Laelay Maichew district, Dimtu(29.63), Dalota (27.78) and Teketay (27.78) were selected by the participant farmers for theire arly maturity (Table 5). On the contrary, Mastewal and localvarieties got less preference based on the above farmer's selection criteria. Farmers selected varieties Dimtu, Dalota and Teketay respectively as 1st, 2nd and 3rd for seed size.

Participant farmers in Laelay Maichew and Tahtay Maichew used the following four traits as most important selection criteria: Earliness, number of pods per plant, Seed size and grain yield. Farmers' preferred early maturing variety producing large number of pods per plant, medium to large seed with high yield. According to Kamaraet al. 2010; Balcha and Tigabu (2015) as cited in [18] and Participatory evaluation and selection of varieties was done to identify the farmers' preference by considering their most important traits.

Considering grain yield most of the farmers in Laelay Miachew selected Teketay (24.07%) followed by varieties Dalota (22.22%) and Dimtu (20.04%) (Table 5). On the other hand, varieties Dimtu (23.91%),Teketay (21.74%) and Dalota (19.74%) were respectively selected by the participant farmers in Tahtay Maichew (Table 4). Similar result and conclusion was reported by Goa and Gezahagn [18] based on the research (measured) data and farmers prefered for Teketay variety in Konta and Tocha Districts in Southern Ethiopia. Similarly, variety Teketay was selected as second important variety next to geletu based on agronomic performance and farmers' preference in north western Ethiopia [19]. A Field study conducted based on grandmother and mother trial on different common bean released varieties in Halaba Special District, Southern Ethiopia reported that inorder to facilitate the adoption rate of varieties, farmers involvement in varital selection and evaluation should be considered [20]**.**

Fig. 2. Farmers' evaluation and selection of desi-chickpea varieties in Laelay Maichew district (Hatsebo) at maturity

Table 4. Farmers'preference ranking of chickpea varieties in the mother trial in Tahtay Maichew(Kewanit) district (n=46), 2019/2020

Variety/Traits	Percent preference				Cumulative (%)	Rank*
	Earliness	NPPL	Seed size	GY		
Teketay	20.37	21.74	26.09	21.74	89.94	3
Dimtu	23.91	21.74	28.26	23.91	97.83	1
Dalota	21.74	19.60	30.43	19.57	91.34	2
Mastewal	17.39	13.04	21.74	17.39	69.57	4
Local	0.00	34.78	0.00	6.52	41.30	5

*NPPL: number ofpod per plant; * 1= Most preferred; 5 = least preferred by the farmers*

Table 5. Farmers' preference ranking of chickpea varieties on the mother in Laelay Maichew (Hatsebo) (n=54), 2019/2020

Varieties/Traits	Percent preference				Cumulative	Rank*
	Earliness	NPP	Seed size	GY	(%)	
Teketay	27.78	20.34	14.81	24.07	87	1
Dimtu	29.63	15	18.52	20.04	83.19	3
Dalota	27.78	16.67	18.52	22.22	85.18	2
Mastewal	9.26	20.37	7.41	14.81	51.85	4
Local	5.56	25.93	0	3.7	35.18	5

NPPL: Number of pods per Plant 1= Most preferred; 5 = least preferred by the farmers*

4. CONCLUSION

To sum up, the tested improved desi chickpea varieties showed better agronomic performance compared to the local variety, except for number of pods per plant. Though the local variety had larger number of pods per plant its grain yield was surpassed by the improved varieties due to their bigger seed size. Farmers in the two districts identified earliness, number of pods per plant (pod load) seed size and yield to be the top variety selection criteria's. The overall ranking of the farmers perception on the evaluated varieties matched with the actual yield and yield components data.

Dimtu and Dalota varieties were selected by farmers as their 1st and 2nd preference respectively in Taetay Maichew(Kewanit) district. Farmers in Laelay Maichew (Hatsebo) district selected Teketay and Dalota as their 1st and 2nd preferrerd varieties, respectively. Hence, Dimtu and Teketay were found to be high yielding and farmers' number one preferred varieties in Tahtay Maichew and Laelay Maichew districts respectively.

Therefore, farmers' participation starting from early plant breeding program could improve farmers' confidence to select their best varieties adaptable to their localities and fasten technology (variety) transfer. Hence, farmers preferred and best fitting varieties could be grown in a large demonstration plot area and thereby scale up to large number of chickpea farmers in the Laelay Maichew and Tahtay Maichew districts and similar agro-ecologies to improve chickpea productivity. The variability in yield and yield components among the desi chickpea varieties could be used for future breeding program.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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