**Release and Registration of *“Hundaol”* Intermediate Maturing type of Cowpea (*Vigna unguiculata* (L.) Walp.) Variety for Mid and Lowland of West Hararghe Zone, Oromia, Ethiopia**

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**Abstract**

*Hundaol” is a name given for the cowpea variety with accession no ILRI#25368. Mechara Agricultural Research Center developed and released the variety for dual-purpose (grain seed and forage) production in the low and mid-altitude areas of West Hararghe and similar agroecologies of the country. “Hundaol” was tested at Mechara Agricultural Research Center on the station, Milkaye FTC, and Melkasa Agricultural Research Center Mieso sub-site for two years of main cropping season 2019- 2021 with other nine genotypes and two standard checks during regional variety trial. Hundaol variety was sown with a seed rate of 30kg/ha, 100 kg/ha NPSB, and 50 kg/ha urea fertilizer rate which was applied at a sowing time with a space of 30 cm between rows. “Hundaol” was selected for its best seed yield, highest dry matter yield, disease and pest tolerance, and stable performance across the locations. “Hundaol” was verified on the station and at the farmer’s field level during the variety verification trial in 2023 with the newly released standard check “Qophee” variety. “Hundaol” produced 9.68 t/ha dry matter yields that have yield advantages of 12.30% and 89.25% over White Wonder and Kenketi standard checks respectively. It produces an average seed yield of 23.28 qt/ha. On average, the “Hundaol” variety has 118.86 cm plant height, 15.3cm, 13.2, and 12.90 pod length, number of pods per plant and seed per pod respectively, needs 67.61 days to reach 50% of flowering, 108.67 days to reach seed maturity. Similarly, the experimental farmers gave the first rank for the “Hundaol” variety rather than the standard check “Qophee” variety. So, the introduction of this newly released forage variety could contribute to relaxing the scarcity of feed resources which is common among the small-scale farmers in West Hararghe and elsewhere in the country.*

*Key words: Dry matter, Hundaol, Variety, West Hararghe*

1. **Introduction**

Cowpea (*Vigna unguiculata* (L.) Walp.) is grown in tropical Africa, Asia, North and South America mostly as a grain, but also as a vegetable and fodder crop. It is favored because of its wide adaptation and tolerance to several stresses. It is an important food source and is estimated to be the major protein source for more than 200 million people in sub-Saharan Africa (OECD 2013). It is an annual herbaceous legume that belongs to Fabaceae family and widely cultivated and consumed grain legumes globally, especially in the arid and semi-arid tropics (Baidoo and Mochiah, 2014; Noubissietchiagam *et al.,* 2010). Cowpea has been produced mainly for its protein rich pulse, popularly consumed with starchy staple foods (Muniu, 2017). Farmers desire varieties that display temporal stability, that is, performing consistently from year to year as opposed to varieties that perform consistently from location to location (spatial stability) (Kang, 2002; Okori *et al.,* 2019). Cowpea plays a fundamental role in the human diet in many developing countries and is being referred to as “poor-man’s meat” (Ravelombola *et al.,* 2016). The grain of cowpea is highly nutritious and contains about 15.06 -38.5% protein (Ravelombola *et al.,* 2016) and 50-60% carbohydrates (Diouf and Hilu, 2005).

Cowpeas vary in growth habit from erect or semi-erect types with short (<100 days) growth duration, grown mostly for grain, to longer (>120 days) duration in semi-erect to trailing plants which are normally grown primarily for forage (Omoigu *et al.*, 2020). It is one of the lowland legumes grown for food, cash crop and medicinal purposes in the different growing areas of Southern Ethiopia (Yasin *et al.,* 2021). It is ranks the 5th to 9th important legume crop for household food, nutrition, and income generation for cultivating farmers, which contributes significantly to food security of the southern region of Ethiopia (Yasin *et al.,* 2021). Generally, cowpea production and utilization in Ethiopia is very low as compared to other African countries though the country is claimed to be the center of diversity and/or origin. The country has high potential for the production of the crop as more than 66.5% of the arable land is very suitable for cowpea production (Collaborative Crop Research Program (CCRP, 2015).

West Hararghe has a suitable agro ecology that helps the production of cowpea. The region has the indigenous knowledge of practicing livestock fattening using different improved forages like Desho grass, Braccharia, Rhodes grass, Napier grass, Cowpea and Alfalfa. Even though thus improved forages are introduced and popularized, searching new varieties that produces higher quality and quantity is very important. Among the quality forage type cowpea could play an important role in providing a significant amount of quality forage, both for the smallholder farmer as well as intensive livestock production systems with appropriate management practices. Hence, the current research is initiated with the objective of to release and register top performing cowpea variety in major agronomic traits, best nutritional quality and stable for in the study area

1. **MATERIALS AND METHODS** 
   1. **Description of the study area**

The study was conducted in West Hararghe zone one mid land (Daro Labu) and one low land (Mieso) district for one year of the main cropping season (2022/23) for variety verification trial.

Daro Labu district is located at latitude of 40°30′ E and 8°10′ N. The district is located at 434 km and 111km to East of capital city of the country, Addis Ababa and Chiro, capital city of the zone respectively. The major soil texture of the district is sandy loam with reddish color. The ambient temperature of the district ranges from 15 to 28°C with the average of 21°C and average annual rainfall of 1120 mm/year (Wasihun, 2021). The predominant production system of the district is mixed livestock-crop production system. The major crops growths in the study area are maize, sorghum, haricot bean, ground nut, sesame and finger millet.Most tree fruits like mango, banana, orange, lemon, hot paper and Avocado also the common one. The especially coffee is the brand crop of the study area known as Hararghe *coffee spatiality*. The major livestock feeds are crop residue (40.67%), green fodder (33.42%), hay (6.65%), by product 2.81%), others and improved forages are (14.71%) and (1.74%) respectively (SCA, 2021). Among improved livestock feeds, Napier grass, Cowpea, Bracharria and Desho grass are widely used as livestock feed. Major livestock species are cattle, goat, donkey, poultry camel and sheep.

Mieso is located 300 km east of Addis Ababa at about 25 km from Chiro the zonal capital city. Geographically, the district is located between 40o 9 30.1 and 40o 56 44"E, and 9o 19 52 N; and 8o 4812"N (Ibrahim, 2012). The altitude is ranges from 1107 to 3106 m above sea level (masl). The mean maximum and mean minimum temperature is 31 and 15 0C respectively with the mean annual temperature of 230C, while average annual rainfall 761 mm ((Wasihun, 2021). According to FAO/UNESCO soil Classification system, the major soils of the district are Vertic Cambisol (orthic and ferralic), Haplic Luvisol (Orthic) and Eutric Cambisol (Orthic), accounting for 50%, 16% and 11%, respectively. The major agricultural activity is livestock raring since it is categorized under one of pastoralist area in the West Hararghe zone. The main livestock reared in the study area are cattle, goat, camel, poultry, donkey and in rear manner sheep. Crop residue is the main livestock feed in the study area. Know a days, the community shift to produce crops like sorghum, maize, sesame, Haricot bean and ground nut and fruit and vegetables like banana, mango and onion.

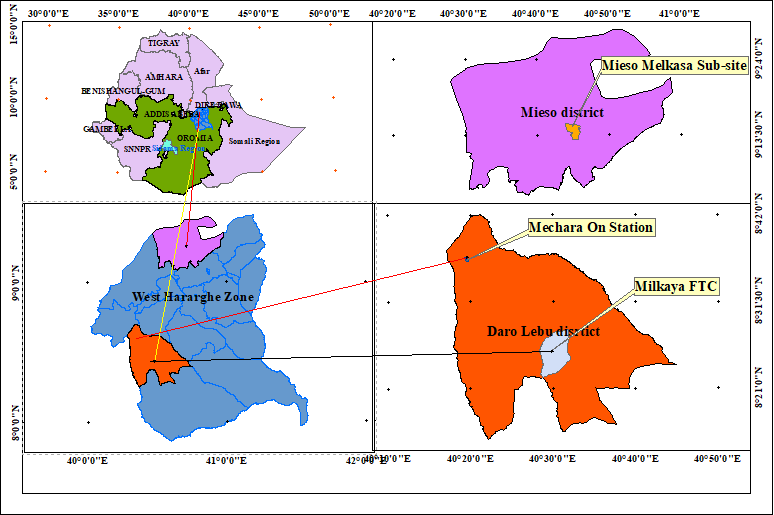


Fig 1. Map of study area

* 1. **Experimental design and layout**

A total of six locations were sown to verify the cowpea genotypes. One candidate cowpea genotype and one newly released standard check considered for this study were ILRI#**25368** genotype and “Qophee” variety. The candidate genotype and newly released was planted in 10 m x 10 m plot size and 30cm between the rows. The seed rate was used 30kg/ha with fertilizer rate 100 kg/ha NPSB and 50 kg/ha of urea fertilizer were applied at a sowing time. The seed was sown through hand drilling techniques.

* 1. **Data collection and measurements**

Most important agronomic data like flowering date, maturity date, plant height, plot cover, disease reaction and occurrence, grain yield data were collected. Also farmer preferences data were collected.

* 1. **Statistical analysis**

Agronomic data and farmers preferences were compared by simple descriptive statistics like means and standard deviation.

1. **Results and Discussions**
   1. **Varietal Origin and Evaluation**

“Hundaol” (ILRI#**25368**) is an intermediate maturing cowpea variety developed by Mechara Agricultural Research center for low and mid land of West Hararghe zone and other similar agro-ecologies of the countries. At the initial, “Hundaol” (ILRI#**25368**) and 179 genotypes of cowpea were collected from the International Livestock Research Institute (ILRI) to evaluate the growth characteristics, agronomic trait, diseases and insects reaction during observation nursery at Mechara Agricultural Research Center during 2017/18 cropping season. Then 34 genotypes cowpea were promoted to the preliminary variety trial during 2018/19. During this step, the genotypes were evaluated for their herbage yield, seed yield and reaction to diseases and insect. From the result of preliminary yield trial, 10 (ten) superior genotypes were passed to regional variety trial which were evaluated at multi location (Mechara on station, Milkaye FTC and Mieso Melkasa Agricultural Research Center sub-site) along with two checks for two years (2019/20 – 2021/22). The checks were White Wonder and Kenketi varieties. From 10 genotypes, ILRI#**25368** (Hundaol) was further selected to promoted for variety verification trials. Genotype ILRI#**25368** (Hundaol) and standard check (Qophee) were planted in 2023 on 10m x 10m =100m2 plots at six locations.The national variety releasing committee were evaluated the varieties under field condition. Finally, Hundaol variety were confirmed and released as intermediate maturing cowpea variety for low and mid land areas of West Hararghe zone and similar agro-ecologies of the Ethiopia.

* 1. **Varietal Characters and Adaptation**

The released variety, “Hundaol” is characterized by growth habit of semi-erect and moderate leaf size. Seed color of “Hundaol” is creamy-white. On the average, “Hundaol” needs 67.61 days to reach 50% of heading/flowering and 108.67 days to reach seed maturity stage. “Hundaol” variety had plant height on average of 118.86 cm at physical maturity of harvest (table 1). The variety also produced on average 13.2 numbers of pod per plant, on average 15.3cm pod length and 12.90 seed per pod (table 2). Hundaol variety is released for the low and mid land of West Hararghe and performed well within an altitude from 1350 -1800 meters above mean sea level.

* 1. **Herbage Dry Matter and Seed Yield Performance**

The average dry matter yield of hundaol variety was 9.68t/ha and standard checks (White Wonder and Kenketi) produced 8.87 t/ha and 5.21 t/ha respectively during multi location variety trial. Hundaol variety produced dry matter yield advantages of 12.30% and 89.25% over White Wonder and Kenketi standard checks varieties respectively. The variety also produced the highest seed yield 23.28 qt/ha that produce seed yield advantage 12.58 and 32.05% over white Wonder and Kenketi standard checks respectively (table 1). During variety verification trial, Hundaol variety was evaluated with recently released variety (Qophee). Hundaol variety produced on average 24.98 qt/ha while Qophee variety produced 20.31 qt/ha which has yield advantage 22.99% over “Qophee” variety (table 2). According to Eberhart and Russel (1966) regression model, Hundaol variety can be considered as more stable than other tested genotypes. The GGE biplot analysis indicated that, the released variety, Hundaol fall to near to the concentric circle to the average environment axis which indicates that, it is ideal genotype in terms of yielding ability and stability.



Fig 2. GGE bi-plot for comparison of genotypes for their yield potential and stability

* 1. **Quality parameters**

Data on the nutritional content of the variety indicated that the Hundaol variety had best crude protein contents of (18.62%), in vitro organic matter digestibility (IVDMD)61.67% and comparatively lower Neutral detergent fiber (NDF) and acid detergent fiber (ADF) which is 44.07% and 35.65% respectively compared to the tested genotypes. The released variety also produced lower total ash content which was 12.25% (Table 2).

* 1. **Reaction to Diseases and Insects**

The most common diseases of Cowpea are Fungal, bacterial and viral diseases. On 1-5 rating scale, Hundaol*,* White Wonder and Kenketiscored a mean of 1.17, 1.5 and 2.33 for Cercospora (leaf spot)which indicate that Hundaol variety is more tolerant variety than the others. Insects were not observed on candidate variety during the experiment duration (table 2 and 3). Hence, the released varieties are characterized by more tolerant to the major diseases at all sites.

* 1. **Farmers Preferences**

Farmer’s preferences were collected for plot cover, biomass yield, stand vigor, leafiness and maturity dates from five experimental farmers of experimental site and three developmental agent workers. The farmers and DA‟s were evaluated through visual observation and hand evaluation. The result indicates that the perceived degree of importance of Hundaol variety was ranked first based on the above criteria’s. Accordingly, the average rank showed that farmers and DA‟s gave the first score for Hundaol variety than the standard check (Qophee) in terms of plot cover, biomass yield, leafiness and stand vigor. The candidate variety was not selected only by maturity date because of its lateness than the standard check (table 4).

Table 1. Mean agronomic performance of cowpea genotypes during multi location test

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | DE | PC | D50F | LSR | PH cm | DI | Pest | MD | DMYtha | SYquha |
| KK | 5.67 | 67.56 | 49.33 | 0.68 | 72.22 | 2.33 | 2.78 | 110.72 | 5.21 | 17.69 |
| 11692 | 5.39 | 83.78 | 60 | 0.75 | 72.41 | 1.72 | 1.89 | 120.89 | 6.79 | 18.08 |
| 9341 | 5.17 | 83.94 | 65.56 | 0.68 | 95.21 | 1.5 | 1.67 | 119.28 | 7.72 | 14.05 |
| 25368 | 5.06 | 92.22 | 67.61 | 0.76 | 118.86 | 1.17 | 1.78 | 108.67 | 9.68 | 23.28 |
| 11971 | 5.67 | 83.06 | 57.28 | 0.69 | 100.09 | 2.17 | 2.11 | 113.39 | 6.41 | 20.8 |
| 9359 | 5.56 | 85.28 | 65.28 | 0.78 | 105.22 | 1.44 | 1.11 | 124.67 | 8.57 | 18.79 |
| 11977 | 5.5 | 90.33 | 59.5 | 0.67 | 107.69 | 1.72 | 2.22 | 114.72 | 6.8 | 21.86 |
| 12735 | 5.22 | 83.89 | 57.28 | 0.60 | 61.74 | 2.06 | 1.39 | 117.61 | 6.1 | 20.33 |
| WW | 5.83 | 86.28 | 62.83 | 0.66 | 93.97 | 1.5 | 1.44 | 119.22 | 8.78 | 20.75 |
| 12737 | 6.17 | 73.78 | 64.61 | 0.78 | 81.14 | 1.5 | 1.67 | 120.5 | 6.64 | 18.26 |
| 25367 | 5.06 | 91.11 | 69.5 | 0.67 | 105.07 | 1.22 | 1.44 | 119 | 7.45 | 17.75 |
| 11988 | 5.56 | 81.56 | 51.89 | 0.71 | 96.89b | 2.44 | 1.89 | 117.17 | 5.92 | 23.3 |
| Mean | 5.48 | 83.56 | 60.87 | 0.7 | 92.54 | 1.75 | 1.78 | 117.15 | 7.18 | 19.75 |
| Genot | \*\*\* | \*\*\* | \*\*\* | NS | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* |
| Env'nt | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | NS | \*\* | \*\*\* | \*\*\* | \*\*\* |
| G\*E | \*\*\* | \*\*\* | \*\*\* | \* | \* | NS | \*\*\* | \*\* | \*\* | NS |
| G\*E\*Y | \*\*\* | \*\* | \*\*\* | \* | \*\* | \*\*\* | NS | \*\*\* | \* | \*\*\* |
| CV | 9.49 | 12.99 | 10 | 26.88 | 22.99 | 45.68 | 35.82 | 5.45 | 34.13 | 32.79 |
| LSD (%) | 0.34 | 7.15 | 4.01 | 0.12 | 14.02 | 0.53 | 0.42 | 4.25 | 1.61 | 4.18 |

KK= Kenket, WW = White Wonder (standard checks), DE = date of emergency, PC = plot cover, D50F = dte of 50% flowering, LSR = leaf stem ratio, PHcm = plant height in cent meter, DI = diseases incidence, DM = maturity date, DMYtha = dry matter yield tone per hectare, SYquha = seed yield quintal per hectare and WW =white wonder

Table: - 2. Mean agronomic performance with “Qophee” variety during variety verification

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Geno | PC | DI | FD | PH | Br | NPOD | PL | SPP | MD | FBMtha | Syqt/ha | Sy adv (%) |
| Qophe | 94.67 | 1.17 | 64.17 | 88.03 | 7.23 | 9.27 | 15.37 | 11.73 | 106.50 | 43.28 | 20.31 | 22.99 |
| 25368 | 97.50 | 1.17 | 67.83 | 107.6 | 7.97 | 13.20 | 15.27 | 12.90 | 108.67 | 57.72 | 24.98 |
| Mean | 96.08 | 1.17 | 66 | 97.82 | 7.60 | 11.23 | 15.32 | 12.32 | 107.58 | 50.50 | 22.65 |  |

Geno= Genotypes, PC= plot cover, DI = Disease Incidence, FD = 50% flowering date; PH = plant height, Br=Branch per plant, PL =Pod length, SPP = seed per pod; MD = Maturity date; FBMtha = Fresh biomass tone per hectare, Syqt/ha = grain yield per hectare, Sy adv(%) = seed yield advantage in percent

Table 3. Chemical compassion of cowpea genotypes

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | %DM | Ash | CP | NDF | ADF | ADL | IVDMD |
| KK | 92.67 | 13.48 | 18.21 | 45.4 | 37.02 | 6.83 | 60.16 |
| 11692 | 92.64 | 13.69 | 18.22 | 45.81 | 37.68 | 6.95 | 59.91 |
| 9341 | 92.79 | 12.54 | 18.02 | 45.32 | 35.22 | 6.64 | 61.67 |
| 25368 | 92.87 | 12.25 | 18.62 | 44.07 | 35.65 | 7.02 | 61.67 |
| 11971 | 92.75 | 13.17 | 18.22 | 45.63 | 37.19 | 6.98 | 60.60 |
| 9359 | 92.94 | 12.82 | 17.54 | 45.68 | 36.7 | 7.01 | 60.31 |
| 11977 | 92.88 | 12.96 | 17.69 | 46.03 | 36.95 | 6.89 | 61.28 |
| 12735 | 92.70 | 13.46 | 18.47 | 44.46 | 35.51 | 6.68 | 60.71 |
| WW | 92.73 | 13.39 | 18.31 | 45.09 | 36.82 | 7.03 | 60.17 |
| 12737 | 92.91 | 13.40 | 17.93 | 47.2 | 38.73 | 7.08 | 60.12 |
| 25367 | 92.69 | 13.22 | 18.16 | 45.36 | 36.77 | 6.97 | 60.77 |
| 11988 | 92.67 | 12.88 | 17.54 | 45.49 | 36.3 | 8.82 | 60.92 |
| Mean | 92.77 | 13.11 | 17.99 | 45.71 | 36.88 | 6.91 | 60.61 |
| CV | 0.18 | 7.95 | 5.15 | 4.05 | 5.86 | 4.82 | 2.58 |
| LSD (%) | 0.29 | 1.76 | 1.57 | 3.14 | 3.66 | 0.56 | 2.65 |
| P-Value | NS | NS | NS | NS | NS | NS | NS |

DM = Dry Matter; CP = Crude Protein; NDF =Neutral detergent fiber; ADF = Acid Detergent Fiber; ADL = Acid detergent lignin; IVDMD = In vitro Dry Matter Digestibility;

Table.4. Farmer preferences Result

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Location (Farmer) | Genotype | plot cover | Biomass yield | Leafiness | stand vigor | Maturity Date |
| On station | ILRI#25368 | 1 | 1 | 1 | 1 | 2 |
| Mieso (MARC) | ILRI#25368 | 1 | 1 | 1 | 1 | 2 |
| Sara | ILRI#25368 | 1 | 1 | 1 | 1 | 2 |
| Sakina FTC | ILRI#25368 | 1 | 1 | 1 | 1 | 2 |
| Getachow | ILRI#25368 | 2 | 2 | 1 | 2 | 1 |
| Yusuf | ILRI#25368 | 1 | 1 | 1 | 1 | 2 |
| Sum |  | **7** | **7** | **6** | **7** | **11** |
| Average (mean) |  | **1.17** | **1.17** | **1** | **1.17** | **1.83** |
| On station | Qophe | 2 | 2 | 2 | 2 | 1 |
| Mieso (MARC) | Qophe | 2 | 2 | 2 | 2 | 1 |
| Sara | Qophe | 2 | 2 | 2 | 2 | 1 |
| Getachow | Qophe | 1 | 1 | 2 | 1 | 2 |
| Sakina FTC | Qophe | 2 | 2 | 2 | 2 | 1 |
| Yusuf | Qophe | 2 | 2 | 2 | 2 | 1 |
| Sum | | **11** | **11** | **12** | **11** | **7** |
| Average (mean) | | **1.83** | **1.83** | **2** | **1.83** | **1.17** |

1 = first, 2 = second, MARC = Melkasa Agricultural Research Center mieso sub-site, FTC = farmer training center

Table.5 Agronomic/morphological characteristics of Cowpea variety, ***Hundaol*** (ILRI#25368)

|  |  |
| --- | --- |
| Characteristics | Description |
| Species | *Vigna unguiculata (L.)* |
| Variety Name | Hundaol |
| Adaptation area | Mechara, Mieso and similar agro ecologies |
| Altitude(m.a.s.l) | 1350 - 1800 |
| Rainfall(mm) | 550 – 950 |
| Fertilizer rate |  |
| Nitrogen(kg N ha-1) | 23 |
| NPS(kg P2O5 ha-1) | 46 |
| Fertilizer application time | At sowing stage |
| Fertilizer application method | Row drilling |
| Planting or seeding | Row drilling |
| Planting date | Early July |
| Seed rate(kg ha-1) | 30 |
| Row spacing(cm) | 30 |
| Plant spacing(cm) | Drilling |
| Days to flowering (days) | 49 to 79 |
| Days to Maturity (days) | 85-118 |
| Plant height(cm) | 108 - 140 |
| Leaf to stem ratio | 0.76 |
| Seed color | Creamy-white |
| Crop pest reaction(1-5 scale) |  |
| Cercospora leaf spot | 1.17 |
| Dry matter yield (t/ha) | 9.68 |
| Fodder Quality (%) |  |
| DM | 92.87 |
| CP | 18.62 |
| IVOMD | 61.67 |
| Ash | 12.25 |
| NDF | 44.07 |
| ADF | 35.65 |
| ADL | 7.02 |
| Special merit | Dual purpose |
| Yield(Qt ha-1) |  |
| Research field | 18.33 - 29.5 |
| Farmers‟ field | 14 - 23 |
| Year of release | 2023 |
| Breeder seed maintainer | Mechara Agricultural Research Center |

**Data Availability**

The Data used to support the findings of this study are available from the corresponding author upon request.

**Disclosure**

No potential conflicts of interest were reported by the authors

**Conflicts of Interest**

The authors declare that they have no conflicts of interest

**Authors’ Contributions**

Tamrat Dinkale, the corresponding author, was responsible for all aspects of the study, including data collection, data analysis, and manuscript writing. Muleta Debela and Birmaduma Gadisa were contributed during proposal development; Lensa Urgesa and Jibrail Hassan were contributed during data collection and contributed to the improvement and finalization of the text, as well as reading and approval of the final edition.

**Acknowledgments**

The authors give special thanks to everyone who helped with data collection, data processing, publishing, and improving this article. The authors would also like to thank the Oromia Agricultural Research Institute, Mechara Agricultural Research Center for financial funding

REFERENCES

[1] Baidoo PK, Mochiah MB (2014). Varietal susceptibility of improved cowpea [Vigna unguiculata (L.) Walp] cultivars to field and storage pests. Sustainable Agricultural Research 3:69-76.

[2] Collaborative Crop Research Program (CCRP) (2015). Collaborative Crop Research program. Cowpea stalk holders workshop,Accra,Ghana.

[3] CSA. (2021). Agricultural sample survey. Report on livestock and livestock characteristics (private peasant holdings). *In the Federal Democratic* *Republic of Ethiopia*. Addis Ababa: Central Statistical Authority.

[4] Diouf D and KW Hilu. 2005. Microsatellites and RAPD markers to study genetic relationships among cowpea breeding lines and local varieties in Senegal. *Genetic Resourcesand Crop Evolution*, 52:1057–1067.

[5] Eberhart, S. T., & Russell, W. A. (1966). Stability parameters for comparing varieties 1. *Crop science*, *6*(1), 36-40.

[6] Ibrahim Ahmed. (2012). *Socio-economic impact of forage development on farm households livelihood in Mieso District, West Hararghe Zone, Oromia National Regional State* (Doctoral dissertation, Haramaya University).

[7] Kang, M. S. (2002). Genotype-environmental interaction: Progress and prospects. In M. S. Kang (Ed.), *Quantitative genetics, genomics and plant breeding* (pp. 221–243). CABI.

[8] Muniu, F. K. (2017). *Characterization and evaluation of local cowpea accessions and their response to organic and inorganic nitrogen fertilizers in coastal Kenya* (Doctoral dissertation, University of Nairobi).

[9] Noubissietchiagam JB, Bell JM, Guissaibirwe S, Gonne S, Youmbi E (2010). Varietal response of cowpea [*Vigna unguiculata* (L.) Walp] to *Striga gesnerioides* (Wild.) Vatke race SG5 infestation. Horticulture, Agrobotanici, Cluj-Napoca 38:33-41.

[10] OECD (Organisation for Economic Co‐operation and Development). (2013). Environment Directorate Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology

[11] Okori, P., Charlie, H., Mwololo, J., Munthali, W., Kachulu, L., Monyo, E., Muitia, A., Mponda, O., Okello, D. K., Makweti, L., & Siambi, M. (2019). Genotype-by- environment interactions for grain yield of Valencia groundnut genotypes in East and Southern Africa. *Australian Journal of Crop Science*, *13*(13(12):2019), 2030–2037.

[12] Omoigui, L. O., Kamara, A. Y., Kamai, N., Ekeleme, F., & Aliyu, K. T. (2020). Guide to cowpea production in Northern Nigeria.

[13] RavelombolaWS, AN Shi, YJ Weng, D Motes, PY Chen, V Srivastava, and C Wingfield. 2016. Evaluation of total seed protein content in eleven Arkansas cowpea [*Vigna unguiculata* (L.) Walp.] lines. *American Journal of Plant Sciences*, 7:2288-2296.

[14] Wasihun Gizaw, 2021. Historical Rainfall Amount and Temperature Variability and Trend in West Harerhge Zone, East Ethiopia. *Mechara Agricultural Research Center unpublished*.

[15] Yasin Goac, Walelign Worku, Hussein Mohammed and Elsia Urage. (2021). Production Constraints, Farmers Preferred-traits and Farming System of Cowpea in the Southern Ethiopia