**Selection of Some Cowpea ( Vigna unguiculata L.) Genotypes for High Forage Yield in Egypt.**

**Abstract**

The present investigation was carried out at the experimental farm of Sakha Agricultural Research Station, Kafrelsheikh Governorate, Agriculture Research Center, Egypt, during 2021, 2022, 2023 and 2024 growing summer seasons. This study was conducted to evaluate 24 cowpea genotypes were selected from base balady population based on morphological traits ,in the second season 2022, 24 selected genotypes with commercial variety Giza18 were sown in a randomized complete block design with three replicates, and select the best twelve genotypes saved to next generation ,in the third season 2023,the best twelve lines with the commercial variety Giza18 were sown, the same design and select the best six genotypes and saved to next generation, in the fourth season 2024,six superior genotypes with the commercial variety Giza18 were sown the same design. The obtained results could be summarized as follows; At the second season, the mean squares of the 24 selected genotypes based on the higher values of fresh and dry forage yield as well as some morphological, technological and chemical traits were found to be significant for all the studied traits.

In the third season , the highest significant for all the studied traits were twelve lines; number 2, 4 , 5, 9 , 10, 11 ,12, 16, 17, 20,21 , and 22 compared to the commercial variety Giza18 , meaning that selection for these traits was effective in improving the studied traits in these materials. High phenotypic variability and genotypic variability were detected for total dry yield, stem diameter and leaf stem ratio %, while moderate (p c v) and (g c v) were detected for plant height, germination %, Seedling length and Seedling fresh weight (g). On the other hand low values of (p c v) and (g c v) were obtained for total fresh yield, no. of tillers / plant, crude protein, crude fiber and Seedling dry weight (g). Moderate to high heritability estimates was noted for the studied traits and ranged from (58.45) for seedling fresh weight (g) to (94.10) for total fresh forage yield kg. / Plot. In the fourth season, the highest significant for all the studied traits, were lines; number4, 9, 10, 16, 20 and 22 compared to the commercial variety Giza18. This study highlights the importance of selecting green and dry forage yield and yield components traits, germination and seedling length in breeding programs to develop high-yielding cowpea varieties.

**Keywords**: fresh forage, dry forage, Phenotypic variability, genotypic variability.

**INTRODUCTION**

Forage Production in Egypt is insufficient in quantity and quality especially in summer season; this is considered to be one of the main problems in feeding animals in the Egypt. So, many studies are done for increasing the forage quantity and quality production. Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important legume crops  **(Bennett-Lartey and Ofori, 1999).** which has the ability to do well even in the drought ,high temperature and other abiotic stress conditions. Cowpea grain contains about 25% protein and 64% carbohydrate (**Ajeigbe *et al*., 2008),** It can be fixed about 240 kg/ ha of atmospheric nitrogen and make available about 60 - 70 kg/ha nitrogen for succeeding crops grown in rotation with it (**Rao and Shahid, 2011).** Cowpea is only fodder crop which contains high protein content and rich in lysine and tryptophan amino acids as compared to other fodder crops (**Ngompe-Deffo *et al*., 2017).** So it plays very important role in feeding animals during summer for its high quality, quantity, and nutritive value.

**(Tarawali *et al*., 1997)** found that cowpea haulm is used to feed the livestock, which later provides manure for soil. So, it was necessary to set a plan to improve forage yield and quality characteristics of cowpea which now is considered an important summer forage crop. Genetic diversity plays an important role in the success of any breeding program (**Ali *et al*., 2008).** Generally, genetic diversity is estimated by measuring variation in phenotypic or quantitative and qualitative traits; however, sometimes it is limited to the characterization of quantitative traits influenced by environmental conditions (**Fernandes *et al*., 2012).** The phenotype is the first and easiest approach for the appraisal of genetic diversity in plant genetic resources, and is useful as a guide to follow-up characterization and evaluation studies (**Bozokalfa *et al.,* 2011).** The assessment of genetic diversity and relationships among cowpea genotypes is of great importance for the determination of agro- morphological properties of gene pool and development of conservation strategies and identification of plant genetic resources (**Martinezgomez *et al*., 2003; EL hamzaoui *et al*., 2014; Rajab *et al*., 2021)** evaluated seventeen cowpea genotypes to detect the magnitude of variability degree of association between the different traits based on the performance of yield and its yield components and seed storage protein. (**El-Nahrawy, 2018)** evaluated 24- cowpea genotypes and found significant for all studied traits in two years Knowledge of genetic diversity in available germplasm and genotypes is very useful for plant improvement all over the world, promoting the efficient use of genetic variations in breeding programs through supporting the proper selection of cross combination among large sets of parental genotypes (**Elteib and Gasim, 2020).**

Improvement in forage crop has to be considered in terms of quality of forage, forage yield, palatability and animal performance which are to be taken into consideration simultaneously. Therefore, It is essential to know the association of various quantitative as well as qualitative characters in order to initiate an effective selection programmer aiming at the improvement of yield and quality of the forage**. (Akhshi *et al*., 2014; Alidu *et al*., 2020).** Wide differences in forage yield were formed among genotypes of fodder cowpea (**Owusu *et al*. 2018).** High genetic variability was observed developing a breeding population aimed at developing high yielding cowpea varieties may result in significant genetic gains as mentioned by (**Chipeta *et al., 2024)****.* Despite its numerous benefits breeding of the cowpea poses a lot of challenges hence its production is not adequate to satisfy domestic demand for the commodity. Although cowpea is a single crop species the varietal requirements in terms of plant type, seed color or type, maturity and use pattern are extremely diverse from region to region, making breeding programs for the crop more complex than for other crops (**Singh *et al*., 1997).** This study was conducted to evaluate 24 cowpea genotypes for fresh and dry forage yield and yield components as well as some morphological, technological and chemical traits and select the best lines with desirable traits for improvement the forage yield in Egypt.

**MATERIALS AND METHODS**

The present investigation was carried out at the experimental farm of Sakha Agricultural Research Station, Kafrelsheikh Governorate, Agriculture Research Center, Egypt, during 2021, 2022, 2023 and 2024 growing summer seasons.

In the first growing season 15 May 2021, 200 seeds of the base balady population and commercial variety Giza 18 were sown in non-replicated rows. Each row 3 m long and spaces between rows were 0.7 m with 30cm between plants. Seeds were sown by hands (3 seeds / hill), plant / hill was maintained. All agriculture practices were carried out as usual for ordinary Cowpea field in the area, at the proper time. At flowering time and harvest the best 24 plants (genotype) were selected based on the higher values of morphological traits (plant height, stem diameter and number of tillers) and saved to the next generation.

In the second season 2022, 24 selected lines with the commercial variety Giza18 were sown in a randomized complete block design with three replicates, Plot size was 6.3m2 ( 3rows, .07m wide and 3m long ) and 20cm between hills. After two weeks, hills were thinned to one plant per hill. Recommended agricultural practices were applied.

The treatments were fertilized with 30 kg P2o5 /fad which were  
added during land preparation and 33 kg N/fad which were divided into two equal parts, part added before the first irrigation and the other after the first cut. Three cuts were taken after50, 90 and 120 days from sowing, respectively.

**Studied traits:**

1- Morphological traits; (i) Total fresh yield (Kg \plot) , (ii) Total dry forage yield (Kg\plot), (iii) Mean plant height (cm)m,(vi) Stem diameter (cm), (v) Number of tillers per plant, and (IV) Percent fresh leave \stem weight. Data was determined at each cutting and averages overall cuts were taken

2-Technological traits were made in seed technology Lab.; (i) Germination (%) according to ISTA, (1999). (ii) Seedling length (cm). and (iii) Seedling fresh and dry weight (g).

3- Chemical traits; (i) crude protein and (ii) Crude fiber according to **AOAC** (2000).

**3.4. Statistical and genetical analyses:**

The variance components from the regular analysis of a randomized complete block design as outlined by **Steel and Torrie (1980)** were used to estimate the phenotypic and genotypic variances as outlined in Table 1.

Table 1. The analysis of variance and expected mean squares.

|  |  |  |  |
| --- | --- | --- | --- |
| S. O .V. | d.F. | M.S | E.M.S. |
| Replications | r-1 | M3 | *σ2****e*** +g *σ2* r |
| Genotypes( families ) | g-1 | M2 | *σ2****e***+ r *σ2* g |
| Error | (r-1)(g-1) | M1 | *σ2****e*** |
| Total | ( r g - 1 ) |  |  |

Where: r and g ; number of replication and genotypes , respectively .

*σ2****e*** and *σ2* g = error variance and genetic variance , respectively .

**The phenotypic and genotypic coefficient of variability:**

The phenotypic ( PCV ) and genotypic ( GCV ) coefficient of variability were calculated as ( *σ* p / ×− ) 100 and ( *σ* g / ×− ) 100 , respectively .

According to **Kearsey and Pooni (1996)**.

Where the genotypic variance *σ2* g = (M2 - M1)/ r and the phenotypic variance *σ2*p = r*σ2* g + *σ2****e***/ r

**Heritability in broad sense** () was estimated as the percentage of genotypic to phenotypic variance as follow:

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The best selected (12) twelve lines saved to the next generation.

In the third season 2023, the best twelve lines with the commercial variety Giza 18 were sown and, the same design, agricultural practices, the studied traits and the statistical and genetical analysis were applied as in the 2022 season. The best six lines were selected and saved to the next generation.

In the fourth season 2024, six superior lines with the commercial variety Giza 18 were sown, the same design, agricultural practices, all the studied traits as well as the statistical and genetical analysis were applied as in the 2023 season.

**RESULTS and DISCUSSION**

Analysis of variance of 24 genotypes showed highly significant for all the studied traits. Indicating the presence of genetic variability among selected lines, it cleared that selection based on the shape and colour of seeds, total fresh yield / plant and total dry yield/plant would be effective. Table (2).

**Table 2**: Analysis of variance for all the studied traits of 24 cowpea genotypes and variety Giza18

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.O.V** | **d. f** | **Total fresh yield**  **kg\plot** | **Total dry yield**  **Kg\plot** | **Plant height**  **(cm)** | **Stem diameter**  **(cm)** | **No. of tillers\plant** | **Leaf \stem ratio%** | **Crude protein (%)** | **Crude fiber (%)** | **Germ. (%)** | **S.L (cm)** | **S.F.W (g)** | **S.D.W (g)** |
| **Rep** | **2** | **1.044** | **0.035** | **9.470** | **0.002** | **0.235** | **31.309** | **0.564** | **3.28** | **11.19** | **0.90** | **0.31** | **0.01** |
| **Gen.** | **24** | **120.3\*\*** | **5.54\*\*** | **69.69\*** | **0.013\*\*** | **1.054\*\*** | **59.83\*\*** | **1.013\*\*** | **0.667\*\*** | **148.541\*\*** | **8.181\*\*** | **0.449\*\*** | **0.147\*\*** |
| **Error** | **48** | **0.253** | **0.113** | **13.212** | **0.001** | **0.056** | **7.037** | **0.078** | **0.102** | **3.790** | **0.362** | **0.086** | **0.008** |

\*, \*\* significant and highly significant at 0.1 % and 0.05 levels of probability, respectively .

Phenotypic, genotypic coefficient of variations, phenotypic coefficients of variability (p c v), and genotypic coefficients of variability (g c v) as well as heritability in broad sense and genetic advances for all the studied traitsare presented in table 3.

Phenotypic and genotypic coefficients of variabilityvaried from one trait to the other. High G C V value of traits suggested the possibility of improving these traits through selection. Data showed that, high phenotypic coefficients of variability (p c v) and genotypic coefficients of variability (g c v) were detected for total dry yield kg. /plot (14.16 and 13.71), stem diameter (10.55 and 9.44) and leaf stem ratio % (11.92 and 6.41) respectively, while moderate phenotypic coefficients of variability (p c v) and genotypic coefficients of variability (g c v) were detected for plant height (9.21 and 7.07), germination % (7.95 and 7.66), seedling length (8.39 and 7.86) and S.F.W. (g) (9.44 and 4.45), respectively. On the other hand low values of (p c v) and (g c v) were obtained for total fresh yield (3.12 and 3.02), no. of tillers / plant (5.24 and 4.82), crude protein (3.76 and 3.39), crude fiber (2.05 and 1.65) and S.D.W. (g) (2.05 and 1.65), respectively.These results agree with **(Mamta *et al.,* 2014; El-Nahrawy, 2018; Rajab *et al.,* 2021; Nkhoma *et al.,* 2020)**

Heritability estimate consider one of the most important parameters to selection response in early generation, indicating the importance of the genetic effects in the inheritance of all the studied traits. Heritability values were estimated from the analysis of variance of lines and commercial variety Giza18 are presented in Table (3). Moderate to high heritability estimates was noted for the studied traits and ranged from (58.45) for S.F.W. (g) to (94.10) for total fresh yield kg. / Plot. The traits; plant height, crude fiber, F. W. (g) and S.D.W. (g) showed moderate heritability estimates (58.77, 64.82, 58.45 and 64.82, respectively), while the other traits showed high heritability estimates. as mentioned with (**El-Nahrawy, 2018 ; Rjab *et al*., 2021; Chipeta *et al., 2024*** ; **Jonah *et al*., 2024).**

**Table 3**: Phenotypic, genotypic coefficient of variations, phenotypic coefficients of variability (p c v), genotypic coefficients of variability (g c v) as well as heritability in broad sense and genetic advances for all the studied traits.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Traits | **Total fresh yield**  **kg\plot** | **Total dry yield**  **Kg\plot** | **Plant height**  **(cm)** | **Stem diameter**  **(cm)** | **No. of tillers\plant** | **Leaf \stem ratio%** | **Crude protein (%)** | **Crude fiber (%)** | **Germ. (%)** | **S.L (cm)** | **S.F.W (g)** | **S.D.W (g)** |
| **X -** | 66.43 | 9.81 | 61.42 | 0.67 | 11.91 | 65.43 | 17.46 | 26.24 | 90.69 | 20.53 | 4.82 | 26.24 |
|  | 4.04 | 1.81 | 18.83 | 0.004 | 0.33 | 17.59 | 0.35 | 0.188 | 48.25 | 2.61 | 0.12 | 0.188 |
| **P** | 4.29 | 1.93 | 32.04 | 0.005 | 0.39 | 24.63 | 0.43 | 0.290 | 52.04 | 2.97 | 0.21 | 0.290 |
| **G. c. v** | 3.02 | 13.71 | 7.07 | 9.44 | 4.82 | 6.41 | 3.39 | 1.65 | 7.66 | 7.86 | 4.45 | 1.65 |
| **p. c .v** | 3.12 | 14.16 | 9.21 | 10.55 | 5.24 | 11.29 | 3.76 | 2.05 | 7.95 | 8.39 | 9.44 | 2.05 |
| **H2%** | 94.10 | 93.78 | 58.77 | 80.0 | 84.61 | 71.14 | 81.39 | 64.82 | 92.71 | 87.87 | 58.45 | 64.82 |
| **GA%** | 4.11 | 18.59 | 7.58 | 11.82 | 6.21 | 7.55 | 4.28 | 1.86 | 10.32 | 10.32 | 7.72 | 1.86 |

With respect to genetic advance ( G A %) , high values were detected for the traits ; total dry forage yield , stem diameter , germination and seedling length . **(Saha *et al.,* 2024)** reported that , the traits which exhibited high heritability and substantial genetic advance, suggesting that direct selection for these traits would be effective

Mean performances of 24 lines and the commercial variety Giza18 for all the studied traits are presented in Table (4)

**Table 4:** mean performance of all the studied traits of 24 lines and commercial variety Giza18 cowpea.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.D.W (g)** | **S.F.W**  **(g)** | **S.L (cm)** | **Germ. (%)** | **Crude fiber (%)** | **Crude protein (%)** | **Leaf \stem ratio%** | **No. of tillers\plant** | **Stem diameter**  **(cm)** | **Plant height**  **(cm)** | **Total Dry yield**  **kg\plot** | **Total Fresh yield**  **Kg\plot** | **Genotypes** |
| **1.50** | **4.70** | **21.00** | **94.90** | **26.57** | **16.56** | **55.99** | **11.63** | **0.65** | **52.89** | **9.42** | **65.73** | **1** |
| **1.90** | **5.93** | **21.57** | **95.00** | **25.87** | **18.10** | **75.72** | **13.92** | **0.67** | **57.89** | **10.06** | **66.65** | **2** |
| **1.52** | **4.40** | **18.50** | **90.00** | **26.77** | **16.40** | **57.89** | **11.28** | **0.67** | **60.00** | **9.17** | **65.50** | **3** |
| **2.10** | **5.68** | **21.47** | **96.40** | **25.67** | **17.90** | **76.11** | **13.20** | **0.73** | **57.55** | **10.84** | **70.23** | **4** |
| **1.90** | **5.52** | **20.53** | **95.67** | **25.63** | **17.47** | **69.55** | **13.11** | **0.68** | **61.44** | **10.15** | **67.10** | **5** |
| **1.53** | **4.13** | **19.63** | **74.00** | **26.67** | **17.00** | **62.81** | **11.13** | **0.63** | **59.33** | **8.37** | **57.07** | **6** |
| **1.70** | **4.30** | **19.57** | **86.67** | **26.76** | **17.17** | **68.96** | **11.34** | **0.67** | **60.78** | **9.00** | **61.37** | **7** |
| **1.70** | **4.70** | **20.57** | **90.00** | **27.27** | **17.40** | **69.11** | **12.06** | **0.58** | **62.44** | **9.72** | **66.23** | **8** |
| **2.10** | **5.65** | **22.57** | **97.00** | **25.60** | **18.00** | **69.57** | **13.87** | **0.71** | **68.11** | **11.18** | **72.00** | **9** |
| **2.23** | **5.50** | **23.77** | **98.67** | **25.47** | **18.80** | **74.47** | **13.14** | **0.82** | **70.11** | **13.68** | **86.07** | **10** |
| **2.03** | **5.55** | **22.67** | **96.33** | **26.00** | **18.13** | **66.42** | **12.06** | **0.73** | **60.55** | **10.41** | **68.63** | **11** |
| **1.77** | **5.57** | **21.57** | **95.00** | **26.27** | **17.87** | **64.67** | **13.34** | **0.69** | **62.89** | **10.47** | **66.70** | **12** |
| **1.47** | **4.67** | **18.00** | **80.33** | **26.67** | **16.93** | **67.22** | **12.27** | **0.61** | **63.89** | **9.52** | **64.93** | **13** |
| **1.80** | **4.20** | **18.80** | **89.67** | **26.73** | **17.33** | **60.44** | **11.82** | **0.56** | **61.00** | **8.75** | **64.00** | **14** |
| **1.67** | **4.03** | **19.43** | **77.00** | **26.43** | **17.07** | **61.00** | **11.27** | **0.72** | **62.56** | **8.11** | **65.80** | **15** |
| **2.10** | **6.65** | **22.23** | **97.00** | **25.93** | **18.33** | **70.79** | **12.52** | **0.73** | **70.17** | **11.49** | **72.43** | **16** |
| **1.93** | **4.96** | **21.27** | **94.00** | **26.37** | **17.83** | **69.13** | **13.39** | **0.68** | **59.67** | **10.18** | **66.76** | **17** |
| **1.63** | **4.86** | **20.00** | **90.33** | **26.27** | **17.03** | **66.22** | **11.13** | **0.69** | **64.33** | **8.47** | **63.50** | **18** |
| **1.70** | **4.67** | **18.57** | **85.33** | **26.50** | **16.80** | **60.00** | **11.06** | **0.63** | **68.89** | **8.31** | **60.83** | **19** |
| **2.13** | **5.68** | **22.13** | **98.00** | **25.57** | **18.17** | **71.95** | **13.31** | **0.76** | **64.34** | **11.58** | **73.73** | **20** |
| **1.90** | **5.48** | **21.77** | **95.67** | **25.87** | **18.00** | **69.67** | **13.40** | **0.69** | **61.22** | **10.58** | **67.82** | **21** |
| **1.80** | **5.68** | **22.10** | **97.00** | **25.97** | **18.07** | **66.12** | **13.47** | **0.73** | **62.78** | **10.65** | **68.57** | **22** |
| **1.60** | **4.86** | **19.67** | **87.33** | **26.57** | **16.73** | **64.89** | **11.84** | **0.66** | **54.67** | **8.78** | **64.27** | **23** |
| **1.60** | **4.70** | **17.00** | **79.67** | **26.57** | **17.00** | **61.00** | **10.94** | **0.52** | **51.67** | **7.37** | **50.23** | **24** |
| **1.77** | **5.00** | **20.00** | **86.33** | **26.13** | **17.30** | **64.11** | **12.13** | **0.67** | **59.37** | **9.85** | **65.70** | **Giza18** |
| **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **F .test** |
| **0.12** | **0.64** | **1.31** | **4.26** | **0.69** | **0.61** | **5.80** | **1.55** | **0.07** | **7.95** | **0.73** | **1.10** | **Lsd0.01** |
| **0.09** | **0.48** | **0.99** | **3.19** | **0.52** | **0.46** | **4.35** | **1.16** | **0.03** | **5.96** | **0.55** | **0.83** | **Lsd0.05** |

For total fresh yield kg/ plot, the lines number2, 4, 5, 9, 10, 11,12,16,17,20,21, and 22 showed significant or highly significant for total fresh yield kg/ plot than the commercial variety Giza18.

The lines number 4, 9, 10, 16, 20, 21 and 22 exhibited significant higher of total dry yield kg / plot than the commercial variety Giza18. While, the other families showed lower for this trait.

Regarding plant height (cm), the lines number 9, 10, 16, and 19 significantly surpassed the commercial variety Giza18 for this trait, while the other lines showed shortest plant height relative to commercial variety. With respect to stem diameter (cm), the lines number 5, 9, 10, 11, 15, 16, 20 and 22 had significantly higher stem diameter relative to commercial variety .

For number of tillers / plant the lines 4, 5, 8, 9, 10, 11, 12, 13, 16, 20, 21, and 22 expressed significant higher number of tillers / plant relative to commercial variety Giza18.

With respect to leaves / stem ratio % the lines number 7, 8, 9, 10, 1 6, 20 and 21 were highly significant compared to commercial variety for this trait.

For crude protein %, the lines number 4, 9, 10, 11, 12, 16, 17, 20, 21 and 22 surpassed the commercial variety Giza18 for crude protein %.

Regarding, crude fiber %, the lines number 4, 6, 7, 12and 14 showed significant or highly significant for crude protein % relative to the commercial variety Giza18. Meanwhile the other lines exhibited less crude fiber %, relative the commercial variety Giza18.

Germination %, ranged from 74.00 % for line no.6 to 98.67 % for line no.10 , also , the results showed that the lines number 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 14, 16, 17, 18, 20, 21 and 22 were highly significant compared to the commercial variety Giza18 for crude protein %.

Regarding seedling length (cm), the lines number 1, 2, 4, 9, 10, 11, 16, 17, 20, 21, and 22 significantly surpassed the commercial variety Giza18 for this trait, while the other lines showed shortest seedling length (cm) relative to commercial variety Giza18.

Seedling fresh weight (g), the lines 4, 5, 9, 10, 11, 16, 19, 20 and 22 exhibited significant higher of Seedling fresh weight (g) than the commercial variety Giza18. While, the other families showed lower for this trait.

Seedling dry weight (g), the lines 4, 5, 9, 10, 11, 16, 17, 20 and 21 exhibited significant higher of Seedling dry weight (g) than the commercial variety Giza18. While, the other families showed lower for this trait.

Generally, the results showed that, the twelve selected lines 2, 4 , 5, 9 , 10, 11 ,12, 16, 17, 20,21 , and 22 significantly out yielded or surpassed the commercial variety Giza18 for most the studied traits, meaning that selection was effective in improving the studied traits in these materials.

Analysis of variance of the best twelve selected lines and commercial variety Giza18 in the third season (2023) showed highly significant for all the studied traits. Indicating the presence of genetic variability among these lines, meaning that selection based on these traits was effective in improving the studied traits in these materials.As *well* as mentioned by **(El-Nahrawy, *2018; Rajab et al., 2021; Saha et al., 2024).***

**Table 5**: Analysis of variance for all the studied traits of 12 lines and cowpea genotypes and commercial variety Giza18.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.O.V** | **d. f** | **Total fresh yield kg\plot** | **Total dry yield**  **Kg\plot** | **Plant height**  **(cm)** | **Stem diameter**  **(cm)** | **No. of tillers\plant** | **Leaf \stem ratio%** | **Crude protein (%)** | **Crude fiber (%)** | **Germ. (%)** | **S.L (cm)** | **S.F.W (g)** | **S. D.W (g)** |
| Rep | **2** | **0.054** | **0.086** | **2.679** | **3.466** | **1.669** | **0.543** | **24.92** | **0.325** | **0.001** | **3.060** | **0.07** | **0.745** |
| Geno | **12** | **0.098\*\*** | **0.230\*\*** | **4.561\*\*** | **99.360\*\*** | **0.321\*\*** | **0.974** | **46.9\*\*** | **1.47\*\*** | **0.008\*\*** | **141.31\*\*** | **4.876\*\*** | **82.76\*\*** |
| Error | **24** | **0.004** | **0.014** | **0.092** | **1.033** | **0.121** | **0.025** | **11.143** | **0.054** | **0.001** | **38.37** | **0.05** | **0.393** |

Phenotypic, genotypic coefficient of variations, phenotypic coefficients of variability (p c v), and genotypic coefficients of variability (g c v) as well as heritability in broad sense and genetic advances of the best twelve selected lines for all the studied traitsare presented in table 6.

Phenotypic and genotypic coefficients of variabilityvaried from one trait to the other. High G C V value of traits suggested the possibility of improving these traits through selection. Data showed that, high phenotypic coefficients of variability (p c v) and genotypic coefficients of variability (g c v) were detected for total fresh yield kg. /plot (9.26 and 8.72), seedling length ( 12.6 and 8.68) and seedling fresh weight (11.06 and10.86 ) respectively, while moderate phenotypic coefficients of variability (p c v) and genotypic coefficients of variability (g c v) were detected for stem diameter , crude protein , germination and seedling dry weight .On the other hand, the other traits showed low phenotypic coefficients of variability (p c v) and genotypic coefficients of variability (g c v).

**Table** 6: Phenotypic, genotypic coefficient of variations, phenotypic coefficients of variability (p c v), genotypic coefficients of variability (g c v) as well as heritability in broad sense and genetic advances of the best twelve selected lines for all the studied traits.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Traits | **Total fresh yield**  **kg\plot** | **Total dry yield**  **Kg\plot** | **Plant height**  **(cm)** | **Stem diameter**  **(cm)** | **No. of tillers\plant** | **Leaf \stem ratio%** | **Crude protein (%)** | **Crude fi ber (%)** | **Germ. (%)** | **S.L (cm)** | **S.F.W (g)** | **S.D.W (g)** |
| **X -** | **2.02** | **5.09** | **22.10** | **94.88** | **26.269** | **18.00** | **68.98** | **12.828** | **0.747** | **67.477** | **11.66** | **71.48** |
|  | **0.031** | **0.07** | **1.32** | **32.77** | **0.213** | **0.31** | **11.93** | **0.475** | **0.002** | **34.315** | **1.606** | **27.32** |
| **P** | **0.035** | **0.08** | **1.41** | **33.80** | **0.332** | **0.34** | **23.07** | **0.529** | **0.003** | **72.683** | **1.664** | **27.72** |
| **G. c. v** | **8.72** | **5.27** | **5.19** | **6.03** | **1.75** | **3.09** | **5.00** | **5.37** | **5.98** | **8.68** | **10.86** | **7.31** |
| **p. c .v** | **9.26** | **5.76** | **5.37** | **6.13** | **2.19** | **3.23** | **6.96** | **5.66** | **7.33** | **12.60** | **11.06** | **7.36** |
| **H2%** | **88.57** | **81.39** | **93.61** | **96.9** | **64.15** | **91.17** | **51.71** | **89.79** | **77.7** | **47.21** | **96.51** | **98.56** |
| **GA%** | **11.48** | **6.56** | **7.04** | **8.31** | **1.96** | **4.13** | **5.04** | **7.12** | **5.95** | **8.35** | **14.94** | **10.16** |

Heritability estimate consider one of the most important parameters to selection response in early generation, indicating the importance of the genetic effects in the inheritance of all the studied traits. Heritability values were estimated from the analysis of variance of lines and commercial variety Giza18 are presented in Table (6). Moderate to high heritability estimates was noted for the studied traits and ranged from (51.71) for crude protein to (98.56) for seedling dry weight.

**Table 7:** mean performances of all the studied traits of 12 lines and commercial variety Giza18 cowpea.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **D. W (g)** | **F.W**  **(g)** | **S.L (cm)** | **Germ. (%)** | **Crude fiber (%)** | **Crude protein (%)** | **Leaf \stem ratio%** | **No. of tillers\plant** | **Stem diameter**  **(cm)** | **Plant height**  **(cm)** | **Total Dry yield**  **kg\plot** | **Total Fresh yield**  **Kg\plot** | **Lines** |
| **1.77** | **5.00** | **22.60** | **94.00** | **26.17** | **17.30** | **67.87** | **12.50** | **0.72** | **65.14** | **11.20** | **69.56** | **2** |
| **2.10** | **5.33** | **22.90** | **96.57** | **25.97** | **18.67** | **68.40** | **12.77** | **0.74** | **66.50** | **12.12** | **72.62** | **4** |
| **2.00** | **5.07** | **20.50** | **97.33** | **25.73** | **17.67** | **67.70** | **12.37** | **0.69** | **64.73** | **11.24** | **69.87** | **5** |
| **2.20** | **5.30** | **23.33** | **97.67** | **25.90** | **18.20** | **71.30** | **13.23** | **0.77** | **73.10** | **12.49** | **73.33** | **9** |
| **2.27** | **5.63** | **24.00** | **99.00** | **25.80** | **19.00** | **76.00** | **14.23** | **0.87** | **81.97** | **15.02** | **86.53** | **10** |
| **2.03** | **4.83** | **23.00** | **98.57** | **26.27** | **18.17** | **67.00** | **12.43** | **0.76** | **64.67** | **11.10** | **69.13** | **11** |
| **2.04** | **5.6** | **22.77** | **97.3** | **26.85** | **18.35** | **67.95** | **13.60** | **0.72** | **65.70** | **11.3** | **68.67** | **12** |
| **2.13** | **5.16** | **22.73** | **97.67** | **26.53** | **18.47** | **72.02** | **13.37** | **0.78** | **79.37** | **12.18** | **73.52** | **16** |
| **1.90** | **4.70** | **21.70** | **95.00** | **26.93** | **17.97** | **66.85** | **12.63** | **0.73** | **66.40** | **10.87** | **68.40** | **17** |
| **2.27** | **5.30** | **22.37** | **98.33** | **26.03** | **18.40** | **73.33** | **13.57** | **0.81** | **69.93** | **12.51** | **74.77** | **20** |
| **2.00** | **5.07** | **21.67** | **95.33** | **26.17** | **18.07** | **72.17** | **12.93** | **0.76** | **65.00** | **11.00** | **68.50** | **21** |
| **2.03** | **5.20** | **22.27** | **98.00** | **26.66** | **18.27** | **69.00** | **13.07** | **0.75** | **65.70** | **11.44** | **70.33** | **22** |
| **1.90** | **4.93** | **20.50** | **87.33** | **26.80** | **17.20** | **63.50** | **12.27** | **0.70** | **62.00** | **10.46** | **67.07** | **Giza18** |
| **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **F .test** |
| **0.43** | **0.27** | **0.69** | **2.32** | **0.85** | **0.35** | **7.54** | **0.58** | **0.58** | **15.44** | **0.55** | **1.43** | **Lsd0.01** |
| **0.32** | **0.19** | **0.51** | **1.7** | **0.61** | **0.26** | **5.57** | **0.41** | **0.05** | **10.94** | **0.41** | **1.06** | **Lsd0.05** |

Generally, the results showed that, the twelve selected lines 2, 4 , 5, 9 , 10, 11 ,12, 16, 17, 20,21 , and 22 significantly out yielded or surpassed the commercial variety Giza18 for most the studied traits, meaning that selection was effective in improving the studied traits in these materials.

**Table 8**: Analysis of variance for all the studied traits of six line cowpea and commercial variety Giza18.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **D. W (g)** | **F.W**  **(g)** | **S.L (cm)** | **Germ. (%)** | **Crude fiber (%)** | **Crude protein (%)** | **Leaf \stem ratio%** | **No. of tillers\plant** | **Stem diameter**  **(cm)** | **Plant height**  **(cm)** | **Total Dry yield**  **kg\plot** | **Total Fresh yield**  **Kg\plot** | **d.f** | **S.O.V** |
| **0.025** | **0.065** | **0.803** | **4.33** | **0.192** | **0.301** | **2.218** | **0.961** | **0.001** | **1.714** | **0.023** | **0.027** | **2** | **Rep** |
| **0.143\*\*** | **0.226\*\*** | **5.504\*\*** | **110.762\*\*** | **0.534\*** | **1.083\*\*** | **81.769\*\*** | **2.687\*\*** | **0.020\*\*** | **284.60\*\*** | **4.537\*\*** | **147.81\*\*** | **6** | **Genotypes** |
| **0.003** | **0.013** | **0.175** | **1.33** | **0.152** | **0.019** | **0.127** | **0.038** | **0.001** | **8.77** | **0.019** | **0.253** | **12** | **Error** |

Analysis of variance of the best six line cowpea and commercial variety Giza18 in the fourth season (2024) showed highly significant for all the studied traits. Indicating the presence of genetic variability among these lines, meaning that selection based on these traits was effective in improving the studied traits in these materials **(El-Nahrawy, 2018; Rajab *et al.,* 2021; Saha *et al.,* 2024; Dairo, 2024).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2.12** | **5.24** | **22.52** | **95.19** | **26.88** | **18.31** | **71.23** | **13.35** | **0.79** | **75.28** | **12.63** | **74.75** | **X -** |
| **0.046** | **0.071** | **1.77** | **36.47** | **0.55** | **0.35** | **27.21** | **0.88** | **0.006** | **91.94** | **1.51** | **49.18** | **g** |
| **0.049** | **0.084** | **1.95** | **37.80** | **0.64** | **0.37** | **27.34** | **0.92** | **0.007** | **100.71** | **1.53** | **49.43** | **P** |
| **10.12** | **5.08** | **5.90** | **6.34** | **2.75** | **3.23** | **7.32** | **7.03** | **9.69** | **12.71** | **9.61** | **9.38** | **G. c. v** |
| **10.44** | **5.53** | **6.20** | **6.46** | **2.97** | **3.32** | **7.34** | **7.18** | **10.47** | **13.33** | **9.77** | **9.40** | **p. c .v** |
| **93.87** | **84.52** | **90.76** | **96.48** | **85.93** | **94.59** | **99.53** | **95.87** | **85.71** | **91.29** | **98.75** | **99.40** | **(H2)%** |
| **13.72** | **6.54** | **7.87** | **8.72** | **3.58** | **4.39** | **10.22** | **9.64** | **12.56** | **17.03** | **13.51** | **13.08** | **GA%** |

**Table 9**: Phenotypic, genotypic coefficient of variations, phenotypic coefficients of variability (p c v), genotypic coefficients of variability (g c v) as well as heritability in broad sense and genetic advances for all the studied traits.

Phenotypic (PCV) and genotypic (GCV) coefficients of variability as well as heritability in broad sense were estimated from the analysis of variance of six line and commercial variety G18 are showed in **Table 9**.

The previous results showed that the differences between PCV and GCV were small, which indicated the importance of genetic variance in the inheritance of all the studied traits, and suggested that the environment had little effect on the expression of these traits.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. D. W (g)** | **S.F.W**  **(g)** | **S.L (cm)** | **Germ. (%)** | **Crude fiber (%)** | **Crude protein (%)** | **Leaf \stem ratio%** | **No. of tillers\plant** | **Stem diameter**  **(cm)** | **Plant height**  **(cm)** | **Total Dry yield**  **kg\plot** | **Total Fresh yield**  **Kg\plot** | **Lines** |
| **2.27** | **5.40** | **23.57** | **98.33** | **26.30** | **18.30** | **72.83** | **13.40** | **0.78** | **75.67** | **12.50** | **73.57** | **9** |
| **2.33** | **5.70** | **24.20** | **99.00** | **26.63** | **19.06** | **76.93** | **14.37** | **0.87** | **84.67** | **15.06** | **87.40** | **10** |
| **2.23** | **5.18** | **23.03** | **98.00** | **26.23** | **18.63** | **73.43** | **13.03** | **0.81** | **77.67** | **12.47** | **74.83** | **16** |
| **2.27** | **5.30** | **22.86** | **98.67** | **26.27** | **18.53** | **75.53** | **13.33** | **0.85** | **77.33** | **12.80** | **75.77** | **20** |
| **2.02** | **5.17** | **22.45** | **96.30** | **27.00** | **18.43** | **72.4** | **13.27** | **0.78** | **68.92** | **11.78** | **69.82** | **21** |
| **2.10** | **5.20** | **22.57** | **98.00** | **27.26** | **18.50** | **70.83** | **13.37** | **0.77** | **75.67** | **11.68** | **70.80** | **22** |
| **1.93** | **5.03** | **20.90** | **91.67** | **27.50** | **18.00** | **64.90** | **12.47** | **0.75** | **69.33** | **11.09** | **67.37** | **Giza18** |
| **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **F .test** |
| **0.14** | **0.27** | **1.04** | **2.88** | **0.74** | **0.34** | **0.88** | **0.48** | **0.07** | **7.38** | **0.33** | **1.25** | **Lsd0.01** |
| **0.09** | **0.19** | **0.74** | **2.03** | **0.53** | **0.24** | **0.63** | **0.15** | **0.05** | **5.23** | **0.23** | **0.88** | **Lsd0.05** |

**Table 10:** mean performance of all the studied traits of six lines and commercial variety Giza18 cowpea.

Generally, the results showed that, the six selected lines;4, 9 , 10, 16, 20 and 22 significantly out yielded or surpassed the commercial variety Giza18 for most the studied traits, indicating wide differences among the genotypes selected and these selected genotypes may be promising at the breeding program to produce superior yielding new varieties (**El-Nahrawy, 2018; Rajab *et* *al.,* 2021; Jonah *et al.,* 2024; Saha *et al.,*** **2024).**

**References**

**Ajeigbe, H. A., Ihedioha, D., & Chikoye, D. (2008).** Variation in physicochemical properties of seed of selected improved varieties of Cowpea as it relates to industrial utilization of the crop. African Journal of Biotechnology, 7(20), 3639–3644.

**Akhshi N, Kianoosh C, Hadi A, Farhad NF (2014).**Generation mean analysis to estimate genetic parameters for morphological traits in common bean (Phaseolus vulgaris L.). Journal of Biodiversity and Environmental Sciences. 4 (3): 254–257.

**Ali ML, Rajewski JF, Baenziger PS, K. S. Gill; K. M. Eskridge and Dweikat L (2008).** Assessment of genetic diversity and relationship among a collection of US sweet sorghum germplasm by SSR markers. Molecular Breeding. 21(4): 497–509.

**Alidu MS, Asante IK Mensah HK (2020).** Evaluation of nutritional and phytochemical variability of cowpea Recombinant Inbred Lines under contrasting soil moisture conditions in the Guinea and Sudan Savanna Agro-ecologies. Heliyon. 6 (2): 1-10.

**AOAC (2000).** Official Methods of Analysis. Association of Official Analytical Chemists. Washington D.C., 16th Edition. pp 223- 225, 992-995.

**Bennet-Lartey S. O. and Ofori I. 1999.** Variability studiesin some qualitative characters of cowpea (Vignaunguiculata (L.) Walp) accessions from four cowpeagrowingregions of Ghana. Ghana J. Agric. Sci. 32: 3-9.

**Bozokalfa M.K., Asciogul,T.K., Eşiyok, D. (2011).** Genetic diversity of farmer-preferred cowpea (Vigna unguiculata L. walp) landraces in Turkey and evaluation of their relationships based on agromorphological traits. Genetika.49 (3): 935- 957.

**Chipeta M M., Esnart N. Y., John K. , Mussa T. , Henriques C.(2024).** Evaluation and identification of high yielding and stable cowpea genotypes using GGE biplot and joint regression analysis for varietal development in East and Southern Africa. Journal of Agriculture and Food Research 18 (2024) 101456.

**EL Hamzaoui, A., A. Oukabli, M. moummi (2014):** Morphological and molecular diversity and genetic structure of Moroccan cultivated almond (Prunus dulcis Mill.) beside some foreign varieties. Plant Gen. Res. Char. Utiliz., 12(3): 308–316.

**El-Nahrawy Shereen M (2018).** Agro-Morphological and Genetic Parameters of some Cowpea Genotypes. Alexandria Science Exchange Journal. 39(1):56-64.

**Elteib AA, and Gasim SM (2020).** Genetic Diversity in the Semi-Arid Grown Cowpea (L. Walp) Accessions Using Morphological and Molecular Characterization. Agricultural Sciences. 11, 692-706.

**Fernandes S. ; D. Antônio; C. Costa; W.R. Silva and L.S. Boiteux (2012).** Genetic analysis of total seed protein content in two cowpea crosses. Crop Sci. 52 (6): 2501–2506.

**ISTA. (1999).** International rules for seed testing. International Seed Testing Association (ISTA), Supplement to Seed Science and Technology, 27: 27-32.

**Jonah PM, Hinekaron JA and Jadong AE.(2024)** Genetic Variability and Heritability Studies in Cowpea Genotypes (*Vigna Unguiculata*. L. Walp): A Review. Ann Rev Resear. 2024; 11(1): 555805. DOI:10.19080/ARR.2024.11.555805.

**Kearsey, M.J. and Pooni, H.S. (1996)** The Genetical Analysis of quantitative Traits. Chapman and Hall, London.380  
<http://dx.doi.org/10.1007/978-1-4899-4441-2>.

**Mamta P, Manpreet, Pahwa K (2014).** Genetic Variability, Correlation and Path Coefficient Analysis in Bittergourd (Momordica charantia L.). International Journal of Advanced Research. 2(8), 179-184.

**Martinez-Gomez, P., S. Arulsekar, D. Potter, T.M. Gradziel (2003):** An extended interspecific gene pool available to peach and almond breeding as characterized using simple sequence repeat (SSR) markers. Euphytica, 131: 313– 322.

**Ngompe-Deffo, T., Kouam, E. B., Beyegue-Djonko, H., andAnoumaa, M. (2017).** Evaluation of the Genetic Variation of Cowpea Landraces (Vigna unguiculata) from Western Cameroon Using Qualitative Traits. Notulae Scientia Biologicae, 9(4): 508-514.

**Nkhoma, N., Shimelis, H., Laing, M.D., Shayanowako, A. and Mathew, I. (2020).** Assessing the genetic diversity of cowpea [Vigna unguiculata (L.) Walp.]germplasm collections using phenotypic traits and SNPmarkers. BMC Genetics, 21:110.

**Owusu EY, Akromah R, Denwar NN, Danquah JA, Kusi F, Haruna M (2018).** Inheritance of Early Maturity in Some Cowpea (Vigna unguiculata (L.) Walp.) Genotypes under Rain Fed Conditions in Northern Ghana. Advances in Agriculture. 4(8):1-10.

**Rajab Magda N. , Mervat R. I. Sayed\* and A. M. A. Abd El- Monem (2021)** Assessing the genetic variability of cowpea (Vigna unguiculata L.) genotypes using phenotypic traits and SDS markers. Direct Research Journal of Agriculture and Food Science: Vol. 9, 2021, ISSN 2354-4147.

**Rao NK, Shahid M (2011).** Potential of cowpea [Vigna unguiculata (L.) Walp.] and guar [Cyamopsis tetragonoloba (L.) Taub.] as alternative forage legumes for the United Arab Emirates. Emir. J. Food Agric., 23 (2): 147-156

**Saha, S. J., Chowdhury, A. K., Rashad, M. M. I., Alam, M. M., & Farhan, S. M. M. (2024).** Genetic variability in exotic cowpea (Vigna unguiculata L.) genotypes. Asian Journal of Medical and Biological Research,10(4),148–156. https://doi.org/10.3329/ajmbr.v10i4.74668

**Singh B. B. and Emechebe A. M. 1997.** Advances in research on cowpea striga and Alectra. In: B. B. Singh, D.Mohan, R. Raj, K. E. Dashiel and L. E. N. Jackai (Eds).Advances in Cowpea Research IITA and JIRCAS. Ibadan,Nigeria. pp. 215-224.

**Steel, R. G. D., and J. H. Torrie (1980)**.Principles and Procedures of Statistics. 2nd ed. New York: McGraw-Hill

**Tarawali, S. A.; Singh, B. B.; Peters, M.; Blade, S. F., 1997**. Cowpea haulms as fodder. In: B. B. Singh, D. R. Mohan Raj, K. Dashiell and L. E. N. Jackai (eds) Advances in Cowpea Research. Co-publication of International Institute of Tropical Agricultural Sciences and the JIRCAS, IITA, Ibadan, Nigeria; 313-325.