# Effect of Water Deficit at different Stages of Development on Forage Yield of Cowpea (*Vigna unguiculata* L.) Genotypes

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**Abstract:** The present study was evaluated fourteen populations of cowpea at Farm of Agriculture Research Station Ismailia, Ismailia Governorate, Egypt. These populations were collected from different regions including one check variety. These were investigated under three levels of watering (100%, 75% and 50% of field capacity), for forage yield, genetic variability and association characters during two successive summer seasons 2017 and 2018 using a Randomized Complete Block Design in a split plot. Analysis of variance was revealed significant variation ($P < 0.05$) among cowpea genotypes for plant length, number of shoots/plant, dry matter percent, forage fresh and dry yields/plot, expected forage fresh and dry yields/fad and water use efficiency. The irrigation levels had non-significant effects on remain traits {*i.e.*: plant length, number of shoots/plant in the second season, leaf/stem ratio, dry matter percent, forage fresh and dry yields/plot, expected forage dry yield/fad and water use efficiency}. Moreover, the irrigation levels and cowpea genotypes-interaction had highly significant differences for the studied traits, excepting of number of shoots/plant. Among the fourteen cowpea genotypes through the three irrigation levels, over two seasons (2017 & 2018); the Kenyan genotype named KF-122 was produced significant more crude protein (24.20%) and crude fiber (27.60%), whilst, this genotype; IN-1-14 was produced significant less crude protein (12.20%) and crude fiber (13.90%), furthermore the, the cheek Egyptian genotype named "Buff" was recorded, approximately, average aforementioned value over two seasons. The phenotypic variance ($\delta^2$p) and phenotypic coefficient of variation (PCV %) were slightly higher than corresponding genotypic variance ($\delta^2$g) and genotypic coefficient of variation (GCV %) for the quantitative forage characters of cowpea indicated the presence of less environmental effect ($\delta^2$e and ECV %) upon the concerned characters. Heritability in broad sense estimates was moderate to high for all studied traits.

***Keywords:*** Cowpea, correlation, drought, forage, genetic parameters, yield and yield components.

## INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is domesticated in Africa and is one of the oldest crops to be farmed. A second domestication event probably occurred in Asia, before, they spread into Europe and Americas. In generally, in the early 2016's, just over 14 million hectares (about 33 million Acres or 33 million Fadden) of land were devoted to grow cowpea worldwide; most of them in African continent (Hectare = 10000 m$^2$, Acre = 4000 m$^2$ and Fadden = 4200 m$^2$).

Plant population in cultivated area is considered an important factor to determine forage and seed yield, particularly, for an annual forage like cowpea, which more affected by a biotic factors such as drought and salinity.

Fodder cowpea (*Vigna unguiculata* L. Walp) is a legume inherently more tolerant to drought than other fodder legumes (Fatokun *et al*., 2009) and considered as a crop capable of improving sustainability of livestock production through its contribution in improving seasonal fodder productivity and nutritive value. In addition to, improvement of drought tolerance in cowpea, through the application of a recurrent selection program, depends on traits being inherited in a quantitative manner (Sousa *et al.,* 2015). Such programs comprise three or more selection cycles conducted in a repetitive manner, such that selection of progenies with enhanced drought tolerance must commence at the first cycle in order to permit future selections. Where, the low yields have been attributed to a number of biotic and a biotic stresses, low yielding local varieties, seed scarcity and poor soils. From these abiotic factors are the drought and salinity. The drought is a situation, whereby, moisture becomes insufficient either due to low precipitation or low soil moisture storage for optimum plant growth.

A drought tolerant and warm weather crop, cowpea is well adapted to the drier regions of the tropics, where other food legumes do not perform well (Simion, 2018). It, also, has the unique ability to fix atmospheric nitrogen through its nodules, and it grows well even in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels of phosphorus.

Its agronomic potential relative to current increasing population and climate change that threaten the world make it a crop of choice for agricultural researchers. It is reported to be well-adapted to high temperatures and drought conditions (Surabhi *et al*., 2009). In addition to being drought tolerant, some varieties have a short production cycle and early mature providing food during the period of hunger, when food becomes extremely scarce in semi-arid regions of sub-Saharan Africa (Cisse and Hall, 2002). Egypt is a country that does not have an abundant supply of water and could well be described as a semi-desert region with a water shortage. Developing drought tolerant varieties is a more sustainable option of managing drought, since; there would be no additional cost to the farmer once drought tolerant seeds are available. Where, drought can cause direct reduction of about 50.00- 67.00% in cowpea seed yield (Fatokun *et al*., 2012; Sanda and Maina, 2013). Nevertheless, breeding for drought tolerance and seed

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yield, however, is complex, because, they are governed by minor genes whose effects are often confounded by interaction of morphological, physiological and biochemical characters of the crop with the environment thus making genetic improvement of these traits in crops a slow and difficult process (Fatokun *et al*., 2012).

In cowpea research, drought tolerant factors have been separated into shoot and root tolerance using simple, rapid and cheap screening methods (Singh and Matsui, 2002; Hall *et al*., 2003). The identification of suitable genotypes, potentially generating superior lines with traits contributing to the overall yield of a crop, is an important step in the development of improved cowpea populations characters, (Moalafi *et al*., 2010; Ayo-Vaughan *et al*., 2013). Based on that, there is a large morphological diversity found within the crop, the growth conditions and grower preferences for each variety vary from region to region. However, as the plant is primarily self-pollinating its genetic diversity within varieties is relatively low. It is also sensitive to soil moisture stress during the vegetative and reproductive growth stages. Screening cowpea for drought tolerance at either vegetative or reproductive stages elsewhere has focused mainly on morphological, biochemical, physiological and yield related indicators. However, under the climate change, drought has been, and is becoming an acute problem mostly constraining plant growth and terrestrial ecosystem productivity, particularly; in arid and semi-arid areas and this effect is definitely reflected on the crop, making it unstable (Xu *et al*., 2010).

In the same contact, stability in yields of agronomical acceptable cultivars is generally regarded as the ultimate goal in cowpea improvement (Oghiakhe *et al.,* 1995) one way to obtain this is to identify genotypes with adequate levels of resistance to drought, heat and other stresses. There is need for cowpea cultivars, which are more tolerant to water deficit or more efficient in water use (Anyia and Herzog, 2004).

On the basis of plant breeding and genetically, cowpea breeding program has become more complex and no single variety can be suitable for all the objectives (Barrett, 1987). Because, on account of diverse uses of cowpea the varietal requirement in term of plant type, seed type, maturity, pattern of use and growth are diverse from region to region. Thus, there is need to develop varieties suitable for a specific region and/or use. Therefore, genetic variability is important to select characters, which are heritable unless and until there is large amount of variability present in the population, the breeder has little scope in breeding for high yielding cowpea varieties. In addition to, genetic association and path analysis are play significant role to study interrelationship contributing of each characters and thus simultaneously for bringing cowpea improvement. Therefore, the aims of this study are, i) to evaluate fourteen populations of cowpea for forage under three levels of irrigation, ii) to estimate the genetic variability, heritability and genetic advance as percent of means among the traits conferring drought tolerance in cowpea at seedling stage and iii) to examine the relationships among studied traits for effective selection of drought tolerant cowpea.

## MATERIAL AND METHODS:

**- Experimental site**

This investigation was done at Ismailia-Agriculture Research Station; Ismailia Governorate, Egypt (Latitude: 30°35′ 0″N, Longitude: 32°16′ 0″E),

- **Plant Materials.**

Fourteen populations of cowpea are collected from different regions including one check variety are use as a plant materials in this experiment**.** The description the fourteen cowpea populations are shown in Table (1) and Fig. (1).

**- Experiments design**

The experiments were laid out in a Randomized Complete Block Design in a split plot arrangement; the main plots were three watering levels and the sub plots were the fourteen cowpea populations.

**- Irrigation System**

Irrigation system including three levels of watering (100%, 75% and 50% of field capacity), for forage yield, genetic variability and association characters during two successive summer seasons 2017 and 2018. Sprinkler irrigation and the sprinkler is half inch and its disposition is 10 litter / hour.

**Table (1):** Description of cowpea populations

| No | Name | Origin | Seed Size | Seed Color | Growth |
|---|---|---|---|---|---|
| **1** | **IT-101** | Italy | Intermediate | White Seeds-Black Eye | Prostrate |
| **2** | **IT-102** | Italy | Intermediate | White Brown Seeds-Black Eye | Prostrate |
| **3** | **IT-103** | Italy | Intermediate | Red Seeds-Black Eye | Prostrate |
| **4** | **KE-118** | Kenya | Small | Dark Brown Seeds-White Eye | Prostrate |
| **5** | **KE-119** | Kenya | Intermediate | Black Seeds-White Eye | Prostrate |
| **6** | **KE-120** | Kenya | Intermediate | Black Seeds-White Eye | Prostrate |
| **7** | **KE-121** | Kenya | Intermediate | Brown Seeds-White Eye | Prostrate |
| **8** | **KE-122** | Kenya | Big | Dark Brown Seeds-White Eye | Prostrate |
| **9** | **KE-123** | Kenya | Intermediate | Black Seeds-White Eye | Erect |
| **10** | **UG-08** | Uganda | Intermediate | White Seeds-White Eye | Prostrate |
| **11** | **NI-04** | Nigeria | Intermediate | Brown Seeds-White Eye | Prostrate |
| **12** | **GHT-35** | Ghana | Big | Black Seeds-White Eye | Prostrate |
| **13** | **IN-1-14** | India | Small | Green Seeds-White Eye | Determinate |
| **14** | **Buff** | Egypt | Intermediate | Dark Brown Seeds- White Eye | Prostrate |

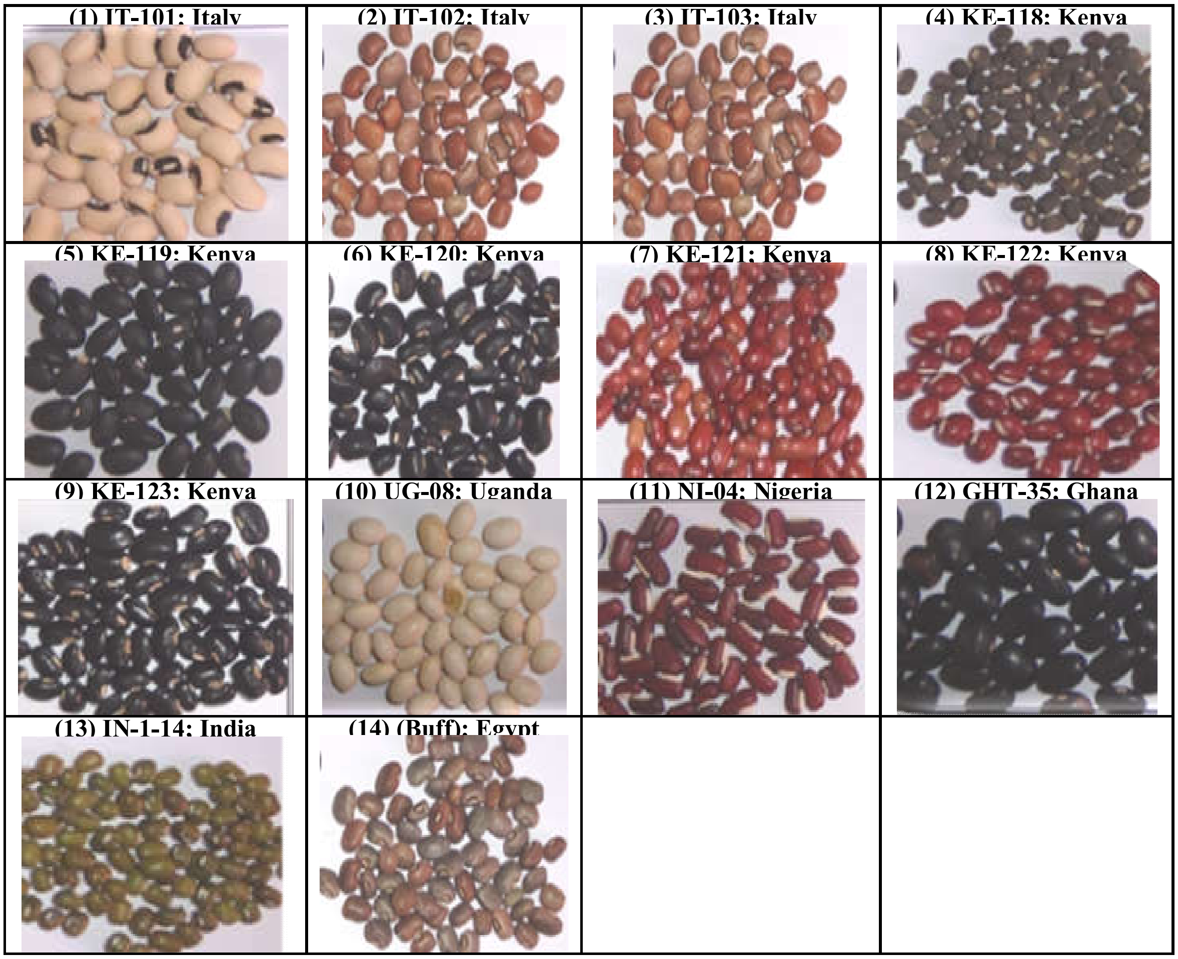


**Fig. (1):** Seed Color and Seed Shape of Cowpea Populations

**- Water Requirement:**

The water requirement was estimated using the FAO Penman-Monteith equation (Cai *et al.*; 2007) as a Follow:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

***Where:***

$ET_o$: Reference evapo-transpiration [mm $day^{-1}$]
$R_n$: Net radiation at the crop surface [MJ $m^{-2}$ $day^{-1}$]
G: Soil heat flux density [MJ $m^{-2}$ $day^{-1}$]
T: Air temperature at 2 m height [°C]
$u_2$: Wind speed at 2 m height [m $s^{-1}$]
$e_s$: Saturation vapour pressure [kPa]
$e_a$: Actual vapour pressure [kPa]
$e_s - e_a$: Saturation vapour pressure deficit [kPa]
Slope vapour pressure curve [kPa $°C^{-1}$]
psychrometric constant [kPa $°C^{-1}$]

Based on that; the total amount of irrigation water received by treatments of experiment unites over season / fadden and irrigation system and it's applied was as follow:

**Table (2):** Total amount of irrigation water / fad. / season; Irrigation system and it's applied

| Items | Three Watering Levels based on Field Capacity | | |
|---|---|---|---|
| | **100%** | **75%** | **50%** |
| **Total amount of irrigation water/fad./season** | 4500.00 $m^3$ | 3375.00 $m^3$ | 2250.00 $m^3$ |
| **Irrigation system and it's applied** | 2:00 hours / 2 days | 1:30 hours / 2 days | 1:00 hour / 2 days |

Notice that; the sprinkler is half inch and sprinkler disposition is 10 litter / hour.

**- Properties of Experimental Soil:**

**Table (3):** Physio-chemical Properties of Soil for Ismailia-Agriculture Research Station

| Parameters | Years | |
|---|---|---|
| | 2017 | 2018 |
| **Sand (%)** | 90.10 | 91.70 |
| **Silt (%)** | 5.40 | 6.30 |
| **Clay (%)** | 2.90 | 3.20 |
| **Soil pH** | 6.60 | 6.80 |
| **Textural class** | Sandy loam | Sandy loam |
| **Organic carbon (%)** | 0.91 | 0.94 |
| **Organic matter (g/kg)** | 2.64 | 2.87 |
| **Total N (%)** | 0.06 | 0.08 |
| **Available P (mg/kg)** | 30.00 | 32.20 |
| **$Ca^{2+}$ (cmol/kg)** | 325.50 | 331.31 |
| **$Mg^{2+}$ (cmol/kg)** | 0.14 | 0.16 |
| **$Na^{+}$ (cmol/kg)** | 0.25 | 0.22 |
| **$K^{+}$ (cmol/kg)** | 0.17 | 0.15 |
| **$Al^{3+}$ (cmol/kg)** | 0.08 | 0.05 |

**Data Collection**

Data was collected on the following growth parameters:

**Forage Yield:**

The forage yield was estimated as an average of four mows by mowed of fixed plot area (1.00 m x 10.00 m = 10.00 $m^2$) and four replications through the two successive years and weighted (kg/plot).

Conformably with plot yield and plot area (10.00 $m^2$), the total fresh yield.$fad^{-1}$ was calculated for the growing season as a follow:

- Plant height (cm) was obtained from measurement of longest stem (main stem) prior to each mow for five plants.
- Number of shoots / plant and number of internodes for main stem were counted.
- Leaf-to-stem weight ratio (LSWR) based on forage fresh weight was estimated from leaves and stems fresh weights {*LSWR = Leaves fresh weight / Stems fresh weight*}.
- Dry matter ratio (DMR) were calculated by dividing the dry weights to fresh weight {*DMR = Dry weights / Fresh weight*}.
- Whole plots were mowed and fresh weights (kg) / plot were measured in the field, then, occasional subsamples (about 0.500 kg) were taken, leaves and stems were separated and weighted to calculate the leaf to stem weight ratio (LSWR).
- After that, forage samples were air dried, oven dried at 105°C for 72 h. and re-weighted to determine dry matter ratio.
- Dry matter weights (kg)/plot were calculated on the basis of the dry matter ratio determined from the subsamples

  {*Dry matter weights (kg) / plot = Fresh weights (kg) / plot x Dry matter ratio*}.
- Conformably with plot yield and plot area (6.00 $m^2$), the total yield·$fa^{-1}$ was calculated for the growing season

  $$\{Yield{\cdot}fa^{-1} = \frac{Plot\ yield\ \ x\ \ 4200\ m^2}{6.00\ m^2}\}.$$
- Water Use Efficiency (WUED):
- The water use efficiency based on dry weight was calculated according to Ehdaie and Waines (1993) formula as a ratio of forage dry yield ($kg/m^3$) to total water consumed (TWC) by the forage crop plants as a follow:

$$\mathbf{WUE}_{(kg{\bullet}m^{-3})} = \mathbf{Y / TWC}$$

**- Forage Quality**

The samples were taken and oven dried at 70°C for 72 h. The sample was conducted following AOAC (1990) methods.

**- Crude Protein (CP)**

Kjeldahl method was used, the catalyst being metallic mercury 0.10 g and 4.00 ml $H_2SO_4$ conc. After clearing, digestion continued for 3 hours and the total nitrogen (N) was determined and multiplied by the factor 6.25 to calculate CP as following formula:

$$\mathbf{CP = N\ x\ 6.25}$$

**- Crude Fiber (CF):**

Samples of 1.00 gm with assistance of H2SO4 and NaOH (1.25%, w/w) were used in CF determination, keeping the column constant with boiling water through automatically fiber apparatus (Takeotor Company). The final residues were washed by acetone, weighed and ashen at 550°C for 3 hours. Determination was according to the method described by AOAC (1990).

**- Data Analysis:**

Data for two seasons was subjected to Analysis of Variance (ANOVA) using Costat version 6.311. Means were separated using L.S.D at 5% levels of significance.

**- Genotypic ($\delta^2$g) and Phenotypic ($\delta^2$p) Variances:**

Genotypic ($\delta^2$g) and phenotypic ($\delta^2$p) variances were estimated according to Burton and De Vane (1953)

**-Phenotypic (PCV %), Genotypic (GCV %) and Environmental (ECV %) Coefficients of Variation:**

The phenotypic coefficient of variation (PCV %), genotypic coefficient of variation (GCV %) and environmental coefficient of variation (ECV %) were estimated by method of Burton (1952) and Johnson *et al*. (1955).

**- Broad Sense Heritability ($h^2_B$):**

Broad sense heritability ($h^2_B$) was expressed as the percentage of the ratio of δg to δp as described by Allard *et al*. (1960)

**- Genetic Advance (GA):**

Genetic Advance (GA) and percentage of the mean (GAM) assuming selection of superior 5% of the genotypes was estimated in accordance with the methods illustrated by Johnson *et al*. (1955) as:

**- Phenotypic Correlation Coefficients:**

In many natural systems; changes in one attribute are accompanied by changes in another attribute and that a definite relation exists between the two. In other words, there are correlations between the two variables. A correlation, whatever its nature, is the ratio of the appropriate covariance to the product of the two standard deviations (Falconer and Mackay, 1996).

## RESULTS AND DISCUSSION

Our primary objective was to evaluate the genetic materials and select of high forage and seed productions genotypes as a basis for improving the productivity of cowpea (*Vigna unguiculata* L. Walp) populations under adverse conditions of drought. Hence, the finding results will be presented in light of the following headings.

### Mean Performance of Forage Yield and quality of Cowpea:

***Forage Yield in Cowpea:***

The mean performances of quantitative forage traits of fourteen cowpea populations exposed to three irrigation levels were ascertained and summarized in Tables (4-12). The analysis of variance was revealed that, the cowpea genotypes under evaluation recorded significant variation ($P < 0.05$) for the forage traits under investigated {*i.e.* plant length, number of shoots/plant, dry matter percent, forage fresh and dry yields/plot, expected forage fresh and dry yields/fad and water use efficiency}. The obtained results were indicated the presence of sufficient variability for the mentioned characters. Therefore, there are a lot of scopes for selection and that one of the ways of assessing the variability is through examining the range of variation and essential for improvement of cowpea genotypes for drought tolerance. In addition to, the statistical analysis was showed that both irrigation levels and genotypes had significant effects on expected forage fresh yield (ton/fad) in the two seasons, but, in the first season only; on number of shoots/plant. With exception of, total forage fresh yield (ton/fad) in the two seasons and number of shoots/lant; in the first season only; the irrigation levels had non-significant effects on remain traits {*i.e*. plant length, number of shoots/plant in the second season, leaf/stem ratio, dry matter percent, forage fresh and dry yields/plot, expected forage dry yield/fad and water use efficiency}. Moreover, the irrigation levels and cowpea genotypes-interaction had highly significant differences for the studied traits, excepting of number of shoots/plant; indicated that, these traits differed between irrigation levels.

Among cowpea genotypes and over two seasons; Kenyan genotype named; KE-122 is produced significantly more plant length (114.90 cm), number of shoots/plant (5.90), leaf/ stem ratio (3.70), dry matter percent (25.75%), total forage fresh yield /plot (93.85 kg), total forage dry yield/plot (23.70 kg), total forage fresh yield/fad (62.568 ton), total forage dry yield/fad (15.795 ton) and water use efficiency (5.04 kg/m$^3$). Less than what we have acquired; Mohamed *et al.* (2013) mentioned that, cowpea forage fresh yield under drip irrigation and saline water ranged from: 2.70 ton/fad at Nekhel district to: 38.70 ton/fad at Rummana district by average mean 17.18 ton /fad.

In contrast; Indian genotype named: IN-1-14 is produced significantly less plant length (58.50 cm), number of shoots/plant (1.80), leaf/stem ratio (1.85), dry matter percent (13.11%), total forage fresh yield/plot (29.60 kg), total forage dry yield/plot dry yield / plot (3.68 kg), total forage fresh yield/fad (19.066 ton), total forage dry yield/fad (2.455 ton) and water use efficiency (0.79 kg/m$^3$). Less more than mentioned; Bilatu *et al*. (2012) reported that, the dry matter yield of cowpea, 4.28 ton.ha$^{-1}$ is recorded in Northwest lowlands of Ethiopia which is comparable to the current study.

While, the check Egyptian genotype named "Buff" were recorded, approximately, average aforementioned values over two seasons, where, plant length was 84.20 cm, number of shoots / plant was 3.65, leaf / stem ratio was 2.85, dry matter percent was 19.52%, total forage fresh yield / plot was 58.50 kg, total forage dry yield / plot was 11.15 kg, total forage fresh yield / fad was 39.97 ton, total forage dry yield / fad was 7.21 ton and water use efficiency was 2.30 kg/m$^3$.

Aboameria (2010) mentioned that, increasing the deficit percent of water application resulted in progressively lower water use efficiency. Where, at 80 % of field capacity, water use efficiency was 0.68 kg/m3, while, it decreased to 0.59 kg/m3 as the deficit percent increased from 80% to 60% of soil moisture content at field capacity. In addition to, Anele *et al.* (2011) reported significant ($P<0.05$) differences in herbage DM yield between commercial and improved cowpea varietal groups. The mean values for herbage DMY recorded in one of the accession (Cowpea-It82d889) are higher than values reported for three commercial (6.46 t/ha) and three improved (8.76 t/ha) groups of cowpea elsewhere. On the other hand, the herbage DMY for Cowpea-82d889 (8.4 t/ha) is comparable with a reported mean value of 8.76 t/ha reported for three improved cowpea cultivars grown in Southwest

Nigeria. Rizk *et al*. (2011) studied the productivity of some summer forage crops under three irrigation rates (1500, 2000 and 2500 m³/fad./ eason) using sprinkler irrigation system in newly reclaimed soil conditions; they found that, the irrigation water rates were significance effective on the total fresh and dry yields of cowpea in both seasons. Where, in the first season, the total fresh yield was; 12.51, 16.82 and 17.64 ton/fad; respectively, by average mean 15.66 ton/fad. More than abovementioned in the second season were; 15.58, 20.05 and 22.58 ton/fad; respectively, by average mean 19.40 ton / fad. Whereas, the total dry yield was; 2.46, 3.33 and 3.44 ton/fad; respectively, by average mean 3.08 ton/fad. While, in the second season were; 3.12, 3.92 and 4.30 ton/fad; respectively, by average mean 3.78 ton / fad. In regard to, the water use efficiency (WUE), they mentioned that, the water use efficiency in the first season was; 1.64, 1.67 and 1.38 kg/m$^3$; respectively, by average mean 1.56 kg/m$^3$. Where, in the second season were; 2.05, 1.97 and 1.73 kg/m$^3$; respectively, by average mean 1.92 kg/m$^3$. Increasing sprinkler irrigation water consumptive use by cowpea from 1500 to 2000 and up to 2500 m$^3$/fad/season was significantly increased the total fresh and dry forage yields as well as the total protein yield per fad. On the other hand, it decreased the water use efficiency in both seasons. On the other hand; Gamachu *et al*. (2017) mentioned that, significant differences (P<0.05) between cowpea accessions in fresh and dry herbage yields during adaptation period in 2012/13 cropping season and cowpea-It82d889 accession was high fresh forage yield (57.91 ton.ha$^{-1}$) compared to the rest accessions. In spite of, the mean fresh weight yield was 38.45 ton. ha$^{-1}$. Dry matter herbage yield was, also, significantly different between accessions at (P<0.05). The highest dry matter yield of 10.4, 8.4, 5.6 ton.ha$^{-1}$ was obtained from a Cowpea-It82d889, Cowpea-82d889 and Cowpea-12688; respectively. The dry matter mean yield obtained was 6.7 ton.ha$^{-1}$ ranged from 4.5 ton.ha$^{-1}$ for Cowpea-17216 to 10.4 ton.ha$^{-1}$ for Cowpea-It82d889.

In addition to, irrigation levels × genotypes interaction mean squares were significant for plant length leaf/stem ratio, dry matter percent, total fresh and dry yield/plot, total fresh and dry yield/fad and water use efficiency (Tables 4-12) indicating that genotype did not perform uniformly across different Irrigation levels. On the contrary, the irrigation levels and cowpea genotypes-interaction for number of shoots/plant was non-significant, indicated a consistency in performance of each genotype across different irrigation levels.

**Table (4):** Effect of Three Irrigation Levels on Plant Length (cm) of Fourteen Cowpea Population during 2017 and 2018-Seasons

| | | **2017** | | | | **2018** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **100%** | **75%** | **50%** | **Mean** | **100%** | **75%** | **50%** | **Mean** |
| **1** | **IT-101** | 102.4 | 89.6 | 67.2 | 86.4 | 110.5 | 96.7 | 72.5 | 93.2 |
| **2** | **IT-102** | 101.5 | 91.3 | 68.4 | 87.1 | 109.5 | 98.5 | 73.8 | 93.9 |
| **3** | **IT-103** | 100.1 | 90 | 67.5 | 85.9 | 108 | 97.1 | 72.8 | 92.6 |
| **4** | **KE-118** | 97.8 | 87.9 | 65.9 | 83.9 | 105.5 | 94.9 | 71.2 | 90.5 |
| **5** | **KE-119** | 99.5 | 89.5 | 67.1 | 85.4 | 107.4 | 96.5 | 72.4 | 92.1 |
| **6** | **KE-120** | 102.3 | 92 | 69 | 87.8 | 110.4 | 99.3 | 74.4 | 94.7 |
| **7** | **KE-121** | 77.8 | 69.9 | 52.4 | 66.7 | 83.9 | 75.4 | 56.6 | 72 |
| **8** | **KE-122** | 128.8 | 115.8 | 86.9 | 110.5 | 139 | 125 | 93.7 | 119.2 |
| **9** | **KE-123** | 107.5 | 96.6 | 72.5 | 92.2 | 116 | 104.3 | 78.2 | 99.5 |
| **10** | **UG-08** | 88.6 | 79.6 | 59.7 | 76 | 95.6 | 85.9 | 64.4 | 82 |
| **11** | **NI-04** | 100.4 | 90.3 | 67.7 | 86.1 | 108.3 | 97.4 | 73 | 92.9 |
| **12** | **GHT-35** | 94.1 | 84.6 | 63.5 | 80.7 | 101.6 | 91.3 | 68.5 | 87.1 |
| **13** | **IN-1-14** | 65.6 | 59 | 44.2 | 56.3 | 70.8 | 63.6 | 47.7 | 60.7 |
| **14** | **Buff** | 94.4 | 84.9 | 63.6 | 81 | 101.9 | 91.6 | 68.7 | 87.4 |
| **G. Mean** | | **97.2** | **87.2** | **65.4** | **83.3** | **65.4** | **94.1** | **70.6** | **89.9** |

| **F-Test** | **F-Values** | **Significances** | **F-Values** | **Significances** |
|---|---|---|---|---|
| **A** | **8.2** | **N.S.** | **4.27** | **N.S.** |
| **B** | **6.17** | ****** | **4.36** | ****** |
| **A x B** | **7.66** | ****** | **4.99** | ****** |

**Table (5):** Effect of three irrigation levels on number of shoots / plant of fourteen cowpea populations affected by three irrigation levels during 2017 and 2018-Seasons

| | | 2017 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 4.1 | 3.7 | 2.8 | 3.5 | 4.4 | 4 | 3 | 3.8 |
| 2 | IT-102 | 3.7 | 3.3 | 2.5 | 3.2 | 4 | 3.6 | 2.7 | 3.4 |
| 3 | IT-103 | 3.9 | 3.5 | 2.6 | 3.3 | 4.2 | 3.8 | 2.8 | 3.6 |
| 4 | KE-118 | 2.2 | 2 | 1.5 | 1.9 | 2.4 | 2.1 | 1.6 | 2 |
| 5 | KE-119 | 3.1 | 2.8 | 2.1 | 2.7 | 3.4 | 3 | 2.3 | 2.9 |
| 6 | KE-120 | 2.8 | 2.6 | 1.9 | 2.4 | 3.1 | 2.8 | 2.1 | 2.6 |
| 7 | KE-121 | 3 | 2.7 | 2 | 2.6 | 3.2 | 2.9 | 2.2 | 2.8 |
| 8 | KE-122 | 6.6 | 5.9 | 4.4 | 5.6 | 7.1 | 6.4 | 4.8 | 6.1 |
| 9 | KE-123 | 4.6 | 3.5 | 2.5 | 3.5 | 4 | 4.2 | 3.2 | 3.8 |
| 10 | UG-08 | 3.6 | 3.2 | 2.4 | 3.1 | 3.9 | 3.5 | 2.6 | 3.3 |
| 11 | NI-04 | 2.7 | 2.4 | 1.8 | 2.3 | 2.9 | 2.6 | 1.9 | 2.5 |
| 12 | GHT-35 | 3.4 | 3.3 | 2.8 | 3.2 | 4 | 3.6 | 2.7 | 3.4 |
| 13 | IN-1-14 | 2 | 1.8 | 1.3 | 1.7 | 2.2 | 1.9 | 1.5 | 1.9 |
| 14 | Buff | 3.9 | 3.7 | 3 | 3.5 | 4 | 4 | 3.4 | 3.8 |
| G. Mean | | 3.5 | 3.2 | 2.4 | 3 | 3.8 | 3.4 | 2.6 | 3.3 |

| F-Test | F-Values | Significances | F-Values | Significances |
|---|---|---|---|---|
| A | 29.71 | * | 3.23 | N.S. |
| B | 3.45 | ** | 5.48 | ** |
| A x B | 1.13 | N.S. | 1.38 | N.S. |

**Table (6):** Effect of Three Irrigation Levels on Leaf / Stem Ratio of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | 2017 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT01 | 2.2 | 2.6 | 3.4 | 2.7 | 2.5 | 3.2 | 3.6 | 3.1 |
| 2 | IT-102 | 1.8 | 2.4 | 3.3 | 2.5 | 2 | 3 | 3.3 | 2.8 |
| 3 | IT-103 | 2.2 | 2.6 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 4 | KE-118 | 2 | 2.5 | 3.2 | 2.6 | 2.3 | 3.1 | 3.1 | 2.8 |
| 5 | KE-119 | 2.2 | 2.6 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 6 | KE-120 | 2.3 | 2.7 | 3.3 | 2.8 | 2.4 | 3.2 | 3.6 | 3.1 |
| 7 | KE-121 | 1.7 | 2.1 | 2.5 | 2.1 | 1.9 | 2.5 | 2.7 | 2.4 |
| 8 | KE-122 | 2.8 | 3.4 | 4.2 | 3.5 | 3.1 | 4.1 | 4.6 | 3.9 |
| 9 | KE-123 | 2.4 | 2.9 | 3.5 | 2.9 | 2.6 | 3.4 | 3.8 | 3.3 |
| 10 | UG-08 | 2 | 2.4 | 2.9 | 2.4 | 2.1 | 2.8 | 3.1 | 2.7 |
| 11 | NI-04 | 2.2 | 2.7 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 12 | GHT-35 | 2.1 | 2.5 | 3.1 | 2.6 | 2.2 | 3 | 3.3 | 2.8 |
| 13 | IN-1-14 | 1.4 | 1.7 | 2.1 | 1.7 | 1.6 | 2.1 | 2.3 | 2 |
| 14 | Buff | 2.1 | 2.5 | 3.1 | 2.6 | 2.2 | 3 | 3.3 | 3.1 |
| G. Mean | | **2.1** | **2.5** | **3.2** | **2.6** | **2.3** | **3.1** | **3.4** | **2.9** |

| F-Test | F-Values | Significances | F-Values | Significances |
|---|---|---|---|---|
| A | 14.86 | N.S. | 8.32 | N.S. |
| B | 6.85 | ** | 6.56 | ** |
| A x B | 2.58 | ** | 4.34 | ** |

**Table (7):** Effect of Three Irrigation Levels on Leaf / Stem Ratio of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| | | 2017 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 2.2 | 2.6 | 3.4 | 2.7 | 2.5 | 3.2 | 3.6 | 3.1 |
| 2 | IT-102 | 1.8 | 2.4 | 3.3 | 2.5 | 2 | 3 | 3.3 | 2.8 |
| 3 | IT-103 | 2.2 | 2.6 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 4 | KE-118 | 2 | 2.5 | 3.2 | 2.6 | 2.3 | 3.1 | 3.1 | 2.8 |
| 5 | KE-119 | 2.2 | 2.6 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 6 | KE-120 | 2.3 | 2.7 | 3.3 | 2.8 | 2.4 | 3.2 | 3.6 | 3.1 |
| 7 | KE-121 | 1.7 | 2.1 | 2.5 | 2.1 | 1.9 | 2.5 | 2.7 | 2.4 |
| 8 | KE-122 | 2.8 | 3.4 | 4.2 | 3.5 | 3.1 | 4.1 | 4.6 | 3.9 |
| 9 | KE-123 | 2.4 | 2.9 | 3.5 | 2.9 | 2.6 | 3.4 | 3.8 | 3.3 |
| 10 | UG-08 | 2 | 2.4 | 2.9 | 2.4 | 2.1 | 2.8 | 3.1 | 2.7 |
| 11 | NI-04 | 2.2 | 2.7 | 3.3 | 2.7 | 2.4 | 3.2 | 3.5 | 3 |
| 12 | GHT-35 | 2.1 | 2.5 | 3.1 | 2.6 | 2.2 | 3 | 3.3 | 2.8 |
| 13 | IN-1-14 | 1.4 | 1.7 | 2.1 | 1.7 | 1.6 | 2.1 | 2.3 | 2 |
| 14 | Buff | 2.1 | 2.5 | 3.1 | 2.6 | 2.2 | 3 | 3.3 | 3.1 |
| G. Mean | | 2.1 | 2.5 | 3.2 | 2.6 | 2.3 | 3.1 | 3.4 | 2.9 |
| F-Test | | F-Values | | Significances | | F-Values | | Significances | |
| A | | 14.86 | | N.S. | | 8.32 | | N.S. | |
| B | | 6.85 | | ** | | 6.56 | | ** | |
| A x B | | 2.58 | | ** | | 4.34 | | ** | |

**Table (8):** Effect of Three Irrigation Levels on Dry Matter (%) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Dry Matter (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 14.93 | 20.37 | 22.26 | 19.19 | 16.11 | 22.5 | 24.55 | 21.05 |
| 2 | IT-102 | 15.21 | 20.74 | 22.07 | 19.34 | 16.41 | 22.9 | 24.34 | 21.22 |
| 3 | IT-103 | 15 | 20.46 | 21.77 | 19.08 | 16.19 | 22.6 | 24.01 | 20.93 |
| 4 | KE-118 | 14.65 | 19.98 | 21.26 | 18.63 | 15.81 | 22.1 | 23.45 | 20.45 |
| 5 | KE-119 | 14.91 | 20.33 | 21.63 | 18.96 | 16.09 | 22.4 | 23.86 | 20.78 |
| 6 | KE-120 | 15.33 | 20.91 | 22.25 | 19.5 | 16.54 | 23.1 | 24.54 | 21.39 |
| 7 | KE-121 | 14.56 | 19.85 | 16.91 | 17.11 | 15.71 | 21.9 | 18.64 | 18.75 |
| 8 | KE-122 | 19.31 | 26.33 | 28.01 | 24.55 | 20.83 | 29.1 | 30.89 | 26.94 |
| 9 | KE-123 | 16.1 | 21.96 | 23.37 | 20.48 | 17.38 | 24.2 | 25.77 | 22.45 |
| 10 | UG-08 | 13.27 | 18.1 | 19.25 | 16.87 | 14.32 | 20 | 21.24 | 18.52 |
| 11 | NI-04 | 15.04 | 20.51 | 21.83 | 19.13 | 16.23 | 22.6 | 24.07 | 20.97 |
| 12 | GHT-35 | 14.1 | 19.23 | 20.46 | 17.93 | 15.22 | 21.2 | 22.57 | 19.66 |
| 13 | IN-1-14 | 9.83 | 13.4 | 14.26 | 12.5 | 10.6 | 14.8 | 15.73 | 13.71 |
| 14 | Buff | 14.14 | 19.29 | 20.52 | 17.98 | 15.26 | 21.3 | 22.63 | 21.05 |
| G. Mean | | 14.74 | 20.1 | 21.13 | 18.66 | 15.91 | 22.2 | 23.31 | 20.47 |
| F-Test | | F-Values | | Significances | | F-Values | | Significances | |
| A | | 11.03 | | N.S. | | 12.93 | | N.S. | |
| B | | 15.01 | | ** | | 14.02 | | ** | |
| A x B | | 9.7 | | ** | | 10.01 | | ** | |

**Table (9):** Effect of Three Irrigation Levels on Total Forage Fresh Yield (kg/Plot) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Total Forage Fresh Yield / Plot (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | **IT-101** | 65.8 | 59.1 | 44.4 | 56.4 | 71 | 63.8 | 47.9 | 60.9 |
| 2 | **IT-102** | 59.3 | 53.3 | 40 | 50.9 | 64 | 57.5 | 43.2 | 54.9 |
| 3 | **IT-103** | 62.4 | 56.1 | 42 | 53.5 | 67.3 | 60.5 | 45.4 | 57.7 |
| 4 | **KE-118** | 35 | 31.5 | 23.6 | 30.1 | 37.8 | 34 | 25.5 | 32.4 |
| 5 | **KE-119** | 50.1 | 45 | 33.8 | 42.9 | 54 | 48.6 | 36.4 | 46.3 |
| 6 | **KE-120** | 45.4 | 40.8 | 30.6 | 38.9 | 49 | 44 | 33 | 42 |
| 7 | **KE-121** | 47.8 | 43 | 32.2 | 41 | 51.6 | 46.4 | 34.8 | 44.2 |
| 8 | **KE-122** | 105.3 | 94.6 | 71 | 90.3 | 113.6 | 102.1 | 76.6 | 97.4 |
| 9 | **KE-123** | 65.1 | 59.4 | 44.8 | 56.4 | 71.9 | 63.3 | 47.5 | 60.9 |
| 10 | **UG-08** | 57.8 | 52 | 39 | 49.6 | 62.4 | 56.1 | 42.1 | 53.5 |
| 11 | **NI-04** | 42.9 | 38.6 | 28.9 | 36.8 | 46.3 | 41.6 | 31.2 | 39.7 |
| 12 | **GHT-35** | 59 | 53.1 | 39.8 | 50.6 | 63.7 | 57.2 | 42.9 | 54.6 |
| 13 | **IN-1-14** | 32.1 | 28.8 | 21.6 | 27.5 | 34.6 | 31.1 | 23.3 | 29.7 |
| 14 | **Buff** | 65.6 | 58.9 | 44.2 | 56.2 | 70.7 | 63.6 | 47.7 | 60.7 |
| **G. Mean** | | **56.7** | **51** | **38.3** | **48.7** | **61.2** | **55** | **41.3** | **52.5** |
| **F-Test** | | **F-Values** | | **Significances** | | **F-Values** | | **Significances** | |
| **A** | | **14.42** | | **N.S.** | | **16.22** | | **N.S.** | |
| **B** | | **9.13** | | ** | | **5.17** | | ** | |
| **A x B** | | **4.48** | | ** | | **2.71** | | ** | |

**Table (10):** Effect of Three Irrigation Levels Total Forage fresh Yield (ton / fedd) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Total Forage Fresh Yield (ton / fad) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | **IT-101** | 43.86 | 39.43 | 29.573 | 37.62 | 47.323 | 42.543 | 31.908 | 40.591 |
| 2 | **IT-102** | 39.552 | 35.557 | 26.668 | 33.93 | 42.675 | 38.365 | 28.773 | 36.604 |
| 3 | **IT-103** | 41.577 | 37.377 | 28.033 | 35.66 | 44.859 | 40.328 | 30.246 | 38.478 |
| 4 | **KE-118** | 23.358 | 20.998 | 15.749 | 20.04 | 25.202 | 22.656 | 16.992 | 21.617 |
| 5 | **KE-119** | 33.375 | 30.005 | 22.503 | 28.63 | 36.01 | 32.373 | 24.28 | 30.888 |
| 6 | **KE-120** | 30.261 | 27.205 | 20.404 | 25.96 | 32.65 | 29.352 | 22.014 | 28.005 |
| 7 | **KE-121** | 31.87 | 28.651 | 21.488 | 27.34 | 34.386 | 30.913 | 23.185 | 29.495 |
| 8 | **KE-122** | 70.177 | 63.089 | 47.317 | 60.19 | 75.717 | 68.069 | 51.052 | 64.946 |
| 9 | **KE-123** | 42.86 | 40.43 | 29.573 | 37.62 | 49.323 | 42.543 | 29.908 | 40.591 |
| 10 | **UG-08** | 38.566 | 34.671 | 26.003 | 33.08 | 41.611 | 37.408 | 28.056 | 35.692 |
| 11 | **NI-04** | 28.6 | 25.711 | 19.284 | 24.53 | 30.858 | 27.741 | 20.806 | 26.468 |
| 12 | **GHT-35** | 39.345 | 35.371 | 26.528 | 33.75 | 42.451 | 38.163 | 28.622 | 36.412 |
| 13 | **IN-1-14** | 21.385 | 19.225 | 14.419 | 18.34 | 23.073 | 20.743 | 15.557 | 19.791 |
| 14 | **Buff** | 43.705 | 39.291 | 29.468 | 37.49 | 47.155 | 42.392 | 31.794 | 40.447 |
| **G. Mean** | | **37.821** | **34.001** | **25.501** | **32.44** | **40.807** | **36.685** | **27.514** | **35** |
| **F-Test** | | **F-Values** | | **Significances** | | **F-Values** | | **Significances** | |
| **A** | | **20.88** | | * | | **20.49** | | * | |
| **B** | | **36.66** | | ** | | **13.9** | | ** | |
| **A x B** | | **12.09** | | ** | | **5.23** | | ** | |

**Table (11):** Effect of Three Irrigation Levels Total Forage Dry Yield (ton/fedd) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Total Forage Dry Yield (ton / fad) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 6.55 | 8.03 | 6.58 | 7.05 | 7.62 | 9.57 | 7.83 | 8.34 |
| 2 | IT-102 | 6.02 | 7.37 | 5.89 | 6.43 | 7 | 8.79 | 7 | 7.6 |
| 3 | IT-103 | 6.24 | 7.65 | 6.1 | 6.66 | 7.26 | 9.11 | 7.26 | 7.88 |
| 4 | KE-118 | 3.42 | 4.2 | 3.35 | 3.66 | 3.98 | 5.01 | 3.98 | 4.32 |
| 5 | KE-119 | 4.98 | 6.1 | 4.87 | 5.32 | 5.79 | 7.25 | 5.79 | 6.28 |
| 6 | KE-120 | 4.64 | 5.69 | 4.54 | 4.96 | 5.4 | 6.78 | 5.4 | 5.86 |
| 7 | KE-121 | 4.64 | 5.69 | 3.63 | 4.65 | 5.4 | 6.77 | 4.32 | 5.5 |
| 8 | KE-122 | 13.55 | 16.61 | 13.25 | 14.47 | 15.77 | 19.81 | 15.77 | 17.12 |
| 9 | KE-123 | 7.06 | 8.66 | 6.91 | 7.54 | 8.22 | 10.3 | 8.22 | 8.91 |
| 10 | UG-08 | 5.12 | 6.28 | 5.01 | 5.47 | 5.96 | 7.48 | 5.96 | 6.47 |
| 11 | NI-04 | 4.3 | 5.27 | 4.21 | 4.59 | 5.01 | 6.27 | 5.01 | 5.43 |
| 12 | GHT-35 | 5.55 | 6.8 | 5.43 | 5.93 | 6.46 | 8.09 | 6.46 | 7 |
| 13 | IN-1-14 | 2.1 | 2.58 | 2.06 | 2.25 | 2.45 | 3.07 | 2.45 | 2.66 |
| 14 | Buff | 6.18 | 7.58 | 6.05 | 6.6 | 7.2 | 9.03 | 7.19 | 7.81 |
| **G. Mean** | | **5.74** | **7.04** | **5.56** | **6.11** | **6.68** | **8.38** | **6.62** | **7.23** |

| F-Test | F-Values | Significances | F-Values | Significances |
|---|---|---|---|---|
| A | 9.94 | N.S. | 5.01 | N.S. |
| B | 23.13 | ** | 25.21 | ** |
| A x B | 3.59 | ** | 8.08 | ** |

**Table (12):** Effect of Three Irrigation Levels Total Forage fresh Yield (ton/fedd) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Total Forage Fresh Yield / Plot (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 1.46 | 2.4 | 2.92 | 2.26 | 1.69 | 2.8 | 3.48 | 2.66 |
| 2 | IT-102 | 1.34 | 2.2 | 2.62 | 2.05 | 1.56 | 2.6 | 3.11 | 2.42 |
| 3 | IT-103 | 1.39 | 2.3 | 2.71 | 2.13 | 1.61 | 2.7 | 3.23 | 2.51 |
| 4 | KE-118 | 0.76 | 1.2 | 1.49 | 1.15 | 0.88 | 1.5 | 1.77 | 1.38 |
| 5 | KE-119 | 1.11 | 1.8 | 2.16 | 1.69 | 1.29 | 2.1 | 2.57 | 1.99 |
| 6 | KE-120 | 1.13 | 1.6 | 2.02 | 1.58 | 1.1 | 2.1 | 2.4 | 1.87 |
| 7 | KE-121 | 1.03 | 1.7 | 1.61 | 1.45 | 1.2 | 2 | 1.92 | 1.71 |
| 8 | KE-122 | 3.01 | 4.9 | 5.89 | 4.6 | 3.5 | 5.9 | 7.01 | 5.47 |
| 9 | KE-123 | 1.57 | 2.6 | 3.07 | 2.41 | 1.83 | 3.1 | 3.65 | 2.86 |
| 10 | UG-08 | 1.14 | 1.9 | 2.23 | 1.76 | 1.32 | 2.2 | 2.65 | 2.06 |
| 11 | NI-04 | 0.96 | 1.6 | 1.87 | 1.48 | 1.11 | 1.9 | 2.23 | 1.75 |
| 12 | GHT-35 | 1.23 | 2 | 2.41 | 1.88 | 1.44 | 2.4 | 2.87 | 2.24 |
| 13 | IN-1-14 | 0.47 | 0.8 | 0.92 | 0.73 | 0.54 | 0.9 | 1.09 | 0.84 |
| 14 | Buff | 1.37 | 2.2 | 2.69 | 2.09 | 1.6 | 2.7 | 3.2 | 2.5 |
| **G. Mean** | | **1.28** | **2.09** | **2.47** | **1.95** | **1.48** | **2.5** | **2.94** | **2.31** |

| F-Test | F-Values | Significances | F-Values | Significances |
|---|---|---|---|---|
| A | 5.58 | N.S. | 5.01 | N.S. |
| B | 24.26 | ** | 13.93 | ** |
| A x B | 13.27 | ** | 7.25 | ** |

***Forage Quality in Cowpea:***

The mean performances of two forage quality traits of fourteen cowpea populations exposed to three irrigation levels were ascertained and summarized in Tables (13-14). The analysis of variance revealed that, the three irrigation levels under evaluation recorded non-significant variation for crude protein and crude fiber traits under investigated during 2017-2018 season; the cowpea populations recorded significant variation ($P < 0.05$) for abovementioned traits. The obtained results indicated the presence of sufficient variability for the mentioned forage quality characters. Therefore, there are a lot of scopes for selection and that one of the ways of assessing the variability is through examining the range of variation and essential for improvement of forage quality in cowpea for drought tolerance. Moreover, the irrigation levels and cowpea genotypes-interaction had significant differences for the studied traits and indicated that, these traits differed between irrigation levels and cowpea genotypes.

Among three irrigation levels, fourteen cowpea genotypes and over two seasons (2017 & 2018); the Kenyan genotype named KF-122 was produced significant more crude protein (24.20%) and crude fiber (27.60%), whilst, this genotype; IN-1-14 was produced significant less crude protein (12.20%) and crude fiber (13.90%). Furthermore the, the cheek Egyptian genotype named "Buff" were recorded, approximately, average aforementioned value over two seasons, where, crude protein was 17.7% and crude fiber was 20.2%, Mohamed *et al.* (2013) mentioned that, the crude protein (CP) was ranged from 21.90% in Rafah-district to 30.10% in Nekhel-district. Equivalently, the crude fiber (CF) was ranged from 23.80% in Rafah-district to 27.80% in Nekhel-district. In Ethiopia, Geloreyouhans and Gebremeskel (2014) found that, the crude protein content was varied from 17.70 to 18.60% with average mean by 18.10%. More than abovementioned; Gondwe *et al.* (2019) found that, the protein content ranged from 25.38% to 27.56% with the significant difference between the improved varieties and the local variety, whereas, the crude fiber content was ranged from 5.81% to 15.08%, with highly significant difference between the improved varieties compared with the local cheek. Whilst; Simion (2018) found the crude protein content ranges from 13 to 17% in cowpea, with low fiber, wherefore; cowpea fodder is a good protein supplement to cereal stalks for feeding livestock.

**Table (13):** Effect of Three Irrigation Levels on Crude Protein (%) of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Crude Protein (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | **IT-101** | 14.4 | 17 | 22.3 | 17.9 | 16.4 | 20.9 | 23.5 | 20.3 |
| 2 | **IT-102** | 11.8 | 15.7 | 21.6 | 16.4 | 13.1 | 19.6 | 21.6 | 18.1 |
| 3 | **IT-103** | 14.4 | 17 | 21.6 | 17.7 | 15.7 | 20.9 | 22.9 | 19.8 |
| 4 | **KE-118** | 13.1 | 16.4 | 20.9 | 16.8 | 15 | 20.3 | 20.3 | 18.5 |
| 5 | **KE-119** | 14.4 | 17 | 21.6 | 17.7 | 15.7 | 20.9 | 22.9 | 19.8 |
| 6 | **KE-120** | 15.1 | 17.7 | 21.6 | 18.1 | 15.7 | 20.9 | 23.5 | 20.1 |
| 7 | **KE-121** | 11.1 | 13.7 | 16.4 | 13.7 | 12.4 | 16.4 | 17.7 | 15.5 |
| 8 | **KE-122** | 18.3 | 22.3 | 27.5 | 22.7 | 20.3 | 26.8 | 30.1 | 25.7 |
| 9 | **KE-123** | 15.7 | 19 | 22.9 | 19.2 | 17 | 22.2 | 24.9 | 21.4 |
| 10 | **UG-08** | 13.1 | 15.7 | 19 | 15.9 | 13.7 | 18.3 | 20.3 | 17.4 |
| 11 | **NI-04** | 14.4 | 17.7 | 21.6 | 17.9 | 15.7 | 20.9 | 22.9 | 19.8 |
| 12 | **GHT-35** | 13.7 | 16.4 | 20.3 | 16.8 | 14.4 | 19.6 | 21.6 | 18.5 |
| 13 | **IN-1-14** | 9.2 | 11.1 | 13.7 | 11.3 | 10.5 | 13.7 | 15 | 13.1 |
| 14 | **Buff** | 14.2 | 16.4 | 20.3 | 17 | 14.4 | 19.6 | 21.6 | 18.5 |
| **G. Mean** | | **13.8** | **16.6** | **20.8** | **17.1** | **15** | **20.1** | **22.1** | **19.1** |

| F-Test | F-Values | Significances | F-Values | Significances |
|---|---|---|---|---|
| **A** | **10.59** | **N.S** | **7.33** | **N.S** |
| **B** | **4.34** | ** | **3.4** | ** |
| **A x B** | **3.63** | ** | **2.9** | ** |

**Table (14):** Effect of Three Irrigation Levels on Crude Fiber (%)of Fourteen Cowpea Populations during 2017 and 2018-Seasons

| No | Populations Name | Crude Fiber (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | |
| | | 100% | 75% | 50% | Mean | 100% | 75% | 50% | Mean |
| 1 | IT-101 | 17.1 | 20.3 | 26.5 | 21.3 | 18 | 23 | 25.9 | 22.3 |
| 2 | IT-102 | 14 | 18.7 | 25.7 | 19.5 | 14.4 | 21.6 | 23.8 | 19.9 |
| 3 | IT-103 | 17.1 | 20.3 | 25.7 | 21 | 17.3 | 23 | 25.2 | 21.8 |
| 4 | KE-118 | 15.6 | 19.5 | 24.9 | 20 | 16.6 | 22.3 | 22.3 | 20.4 |
| 5 | KE-119 | 17.1 | 20.3 | 25.7 | 21 | 17.3 | 23 | 25.2 | 21.8 |
| 6 | KE-120 | 17.9 | 21 | 25.7 | 21.5 | 17.3 | 23 | 25.9 | 22.1 |
| 7 | KE-121 | 13.2 | 16.4 | 19.5 | 16.4 | 13.7 | 18 | 19.4 | 17 |
| 8 | KE-122 | 21.8 | 26.5 | 32.7 | 27 | 22.3 | 29.5 | 33.1 | 28.3 |
| 9 | KE-123 | 18.7 | 22.6 | 27.3 | 22.9 | 18.7 | 24.5 | 27.4 | 23.5 |
| 10 | UG-08 | 15.6 | 18.7 | 22.6 | 19 | 15.1 | 20.2 | 22.3 | 19.2 |
| 11 | NI-04 | 17.1 | 21 | 25.7 | 21.3 | 17.3 | 23 | 25.2 | 21.8 |
| 12 | GHT-35 | 16.4 | 19.5 | 24.1 | 20 | 15.8 | 21.6 | 23.8 | 20.4 |
| 13 | IN-1-14 | 10.9 | 13.2 | 16.4 | 13.5 | 11.5 | 15.1 | 16.6 | 14.4 |
| 14 | Buff | 16.8 | 19.5 | 24.1 | 20.1 | 15.8 | 21.6 | 23.8 | 20.4 |
| G. Mean | | 16.4 | 19.8 | 24.8 | 20.3 | 16.5 | 22.1 | 24.3 | 21 |
| F-Test | | F-Values | | Significances | | F-Values | | Significances | |
| A | | 3.72 | | N.S | | 6.32 | | N.S | |
| B | | 4.82 | | ** | | 4.31 | | ** | |
| A x B | | 2.29 | | ** | | 2.98 | | ** | |

**Genetic Variability, Heritability and Genetic Advance of Forage Yield in Cowpea:**

Genetic variability in cowpea populations is very important, because, without variability, it becomes difficult for a population to adapt to environmental changes and plays a very important role in cowpea breeding program. Where, estimates of genetic components are basic information needed for the cowpea breeders to improve the cowpea by adopting appropriate method of selection based on variability that exist in the material, hence, partition the total variability into heritable and non-heritable components *viz*., phenotypic and genotypic variances and phenotypic and genotypic coefficients of variation and broad sense heritability.

In the present study, genetic variability, heritability and genetic advance of quantitative forage traits of fourteen cowpea populations exposed to three irrigation levels were estimated and summarized in Tables (15-17). The phenotypic variance ($\delta^2$p) and phenotypic coefficient of variation (PCV%) were slightly higher than corresponding genotypic variance ($\delta^2$g) and genotypic coefficient of variation (GCV%) for the ten quantitative forage characters of cowpea under study indicated the presence of less environmental effect ($\delta^2$e and ECV%) upon the concerned characters.

The values of phenotypic (PCV%) genotypic (GCV%) and environmental (ECV%) coefficients of variation were categorized as low (<10%), moderate (10 to 20%) and high (>20%) based on the divided by Sivasubramanian and Menon (1973) and exposed in Tables (14-17). As average mean over two seasons; the high estimated values were recorded in case of number of shoots / plant (91.53, 60.17 and 68.97; respectively), leaf / stem ratio (172.45, 132.47 and 110.42; respectively), forage dry yield / plot (56.83, 41.90 and 38.39; respectively), expected forage dry yield/fad (117.24, 108.42 and 44.60; respectively) and water use efficiency (329.84, 138.46 and 142.25; respectively). In addition to, but only, for phenotypic (PCV %) and genotypic (GCV%) coefficients of variation levels; the high estimated values were recorded for dry matter percent (33.83, and 29.75; respectively) and expected forage fresh yield/fad (27.05, and 24.73; respectively). Likewise, Nath and Tajane (2014) mentioned that; the GCV and PCV were highest for green forage yield/plant, followed by dry matter yield / plant. In addition to, El-Nahrawy (2018) found higher PCV values than GCV, in the first season, which indicates of some environmental implication alongside genotypic reasons of variation observed between varieties used in this study.

In contrast and, also, according to Sivasubramanian and Menon (1973); the low estimated value (<10%) was recorded for plant length trait, where, the genotypic coefficient of variation was 7.42%. Moreover, environmental coefficient of variation for plant length was 7.45% (Table 14) and 9.13% for forage fresh yield/plot (Table 15). While, the moderate values (10 to 20%) were recorded for forage fresh yield/plot, where, PCV was 14.36% and GCV was 11.08% and ECV was 16.11% for dry matter percent and 10.95% for expected forage fresh yield/fad (Table 15).

**Table (15):** Mean squares and genetic parameters for plant Length, number of shoots / plant and leaf/stem ratio of fourteen cowpea populations affected by three irrigation levels during 2017 and 2018-Seasons

| Source of Variation | d.f. | Three Forage yields Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant Length (cm) | | | Number of shoots / Plant | | | Leaf / Stem Ratio | | |
| | | 2017 | 2018 | Mean | 2017 | 2018 | Mean | 2017 | 2018 | Mean |
| **Replications** | 4-1=3 | 221.23 | 183.34 | 202.29 | 7.65 | 11.03 | 9.34 | 17.28 | 22.89 | 20.09 |
| **Irrigation Levels (A)** | 3-1=2 | 285.45 | 223.49 | 254.47 | 91.50 | 18.24 | 54.87 | 73.40 | 102.21 | 87.81 |
| **Main Plot Error (a)** | 3x2=6 | 34.80 | 52.36 | 43.58 | 3.08 | 5.64 | 4.36 | 4.94 | 12.28 | 8.61 |
| **Cowpea Genotypes (B)** | 14-1=13 | 171.68 | 241.56 | 206.62 | 22.95 | 15.23 | 19.09 | 85.75 | 38.85 | 62.30 |
| **A x B** | 2x13=26 | 213.18 | 276.80 | 244.99 | 7.53 | 3.84 | 5.69 | 32.34 | 25.67 | 29.01 |
| **Sub Plot Error (b)** | 3x3x13=117 | 27.84 | 55.43 | 41.64 | 6.66 | 2.78 | 4.72 | 12.52 | 5.92 | 9.22 |
| **Total** | (4x3x14)-1=167 | 954.18 | 1032.98 | 993.59 | 139.37 | 56.76 | 98.07 | 216.23 | 207.82 | 212.03 |
| **Average Mean:** | | 83.30 | 89.90 | 86.60 | 3.00 | 3.30 | 3.15 | 2.60 | 2.90 | 2.75 |
| **Genetic parameters** | | | | | | | | | | |
| **Phenotypic Variance ($\delta^2$p)** | | 63.80 | 101.96 | 82.89 | 10.73 | 5.89 | 8.31 | 30.83 | 14.15 | 22.49 |
| **Genotypic Variance ($\delta^2$g)** | | 35.96 | 46.53 | 41.25 | 4.07 | 3.11 | 3.59 | 18.31 | 8.23 | 13.27 |
| **Environmental Variance ($\delta^2$e)** | | 27.84 | 55.43 | 41.64 | 6.66 | 2.78 | 4.72 | 12.52 | 5.92 | 9.22 |
| **Phenotypic Coefficients of Variation (PCV %)** | | 9.59 | 11.23 | 10.51 | 109.20 | 73.56 | 91.53 | 213.55 | 129.72 | 172.45 |
| **Genotypic Coefficients of Variation (GCV %)** | | 7.20 | 7.29 | 7.42 | 67.27 | 53.46 | 60.17 | 164.57 | 98.94 | 132.47 |
| **Environmental Coefficients of Variation (ECV %)** | | 6.33 | 8.28 | 7.45 | 86.02 | 50.53 | 68.97 | 136.09 | 83.90 | 110.42 |
| **Broad Sense Heritability ($h^2_B$)** | | 56.36 | 45.64 | 49.77 | 37.95 | 52.82 | 43.22 | 59.39 | 58.17 | 59.00 |
| **Genetic Advance (GA)** | | 9.29 | 9.51 | 9.35 | 2.56 | 2.65 | 2.57 | 6.80 | 4.51 | 5.77 |
| **Genetic Advance as Percentage of Mean (GAM)** | | 11.15 | 10.57 | 10.79 | 85.48 | 80.16 | 81.61 | 261.63 | 155.67 | 209.91 |

***Note:*** Classify of PCV %, GCV % and ECV % according to Sivasubramanian and Menon (1973) as: Low: 0-10%; Moderate: 10- 20% and High: > 20%. Categorize of broad sense heritability according to Robinson *et al.* (1949) as: Low: 0-30%; Moderate: 30- 60% and High: > 60%.
Categorize of genetic advance as percentage of mean according to Johnson *et al*. (1955) as: Low: 0-10%; Moderate: 10- 20% and High: > 20%.

**Table (16):** Mean squares and analysis of variance for leaf stem ratio, dry matter (%) and forage fresh yield / plot (kg) of fourteen cowpea populations affected by three irrigation levels during 2017 and 2018-Seasons

| Source of Variation | d.f. | Three Forage yields Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (%) Dry Matter | | | Forage Fresh Yield / Plot (kg) | | | Forage Dry Yield / Plot (kg) | | |
| | | 2017 | 2018 | Mean | 2017 | 2018 | Mean | 2017 | 2018 | Mean |
| **Replications** | 4-1=3 | 19.23 | 9.28 | 14.26 | 124.85 | 136.66 | 130.76 | 54.61 | 85.13 | 69.87 |
| **Irrigation Levels (A)** | 3-1=2 | 211.59 | 123.59 | 167.59 | 74.68 | 132.23 | 103.46 | 59.18 | 115.32 | 87.25 |
| **Main Plot Error (a)** | 3x2=6 | 19.18 | 9.56 | 14.37 | 5.18 | 8.15 | 6.67 | 12.25 | 7.18 | 9.715 |
| **Cowpea Genotypes (B)** | 14-1=13 | 189.84 | 101.21 | 145.53 | 169.25 | 125.11 | 147.18 | 57.16 | 113.81 | 85.485 |
| **A x B** | 2x13=26 | 122.72 | 72.24 | 97.48 | 83.05 | 65.42 | 74.24 | 62.22 | 57.96 | 60.09 |
| **Sub Plot Error (b)** | 3x3x13=117 | 12.65 | 7.22 | 9.94 | 18.53 | 24.18 | 21.36 | 7.13 | 22.53 | 14.83 |
| **Total** | (4x3x14)-1=167 | 575.21 | 323.10 | 449.17 | 475.54 | 491.75 | 483.65 | 252.55 | 401.93 | 327.24 |
| **Average Mean:** | | 19.57 | 18.66 | 20.47 | 50.60 | 48.70 | 52.50 | 9.22 | 10.84 | 10.03 |
| **Analysis of Variance:** | | | | | | | | | | |
| **Phenotypic Variance ($\delta^2$p)** | | 56.95 | 30.72 | 43.84 | 56.21 | 49.41 | 52.82 | 19.64 | 45.35 | 32.49 |
| **Genotypic Variance ($\delta^2$g)** | | 44.30 | 23.50 | 33.90 | 37.68 | 25.23 | 31.46 | 12.51 | 22.82 | 17.66 |
| **Environmental Variance ($\delta^2$e)** | | 12.65 | 7.22 | 9.94 | 18.53 | 24.18 | 21.36 | 7.13 | 22.53 | 14.83 |
| **Phenotypic Coefficients of Variation (PCV %)** | | 40.44 | 27.08 | 33.83 | 15.39 | 13.39 | 14.36 | 48.06 | 62.12 | 56.83 |
| **Genotypic Coefficients of Variation (GCV %)** | | 35.67 | 23.68 | 29.75 | 12.60 | 9.57 | 11.08 | 38.36 | 44.07 | 41.90 |
| **Environmental Coefficients of Variation (ECV %)** | | 19.06 | 13.13 | 16.11 | 8.84 | 9.37 | 9.13 | 28.96 | 43.79 | 38.39 |
| **Broad Sense Heritability ($h^2_B$)** | | 77.79 | 76.50 | 77.32 | 67.03 | 51.07 | 59.56 | 63.69 | 50.32 | 54.36 |
| **Genetic Advance (GA)** | | 12.11 | 8.75 | 10.56 | 10.37 | 7.41 | 8.93 | 5.82 | 6.99 | 6.39 |
| **Genetic Advance as Percentage of Mean (GAM)** | | 64.90 | 42.73 | 53.97 | 21.29 | 14.11 | 17.65 | 63.15 | 64.49 | 63.74 |

**Table (17):** Mean squares and analysis of variance for forage dry yield / plot (kg) forage fresh yield / fad (ton) and forage dry yield / fad (ton) of fourteen cowpea populations affected by three irrigation levels during 2017 and 2018-Seasons

| Source of Variation | d.f. | Three Forage yields Traits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Expected Forage Fresh Yield / fad (ton) | | | Expected Forage Dry Yield / fad (ton) | | | Water Use Efficiency (kg/m3) | | |
| | | 2017 | 2018 | Mean | 2017 | 2018 | Mean | 2017 | 2018 | Mean |
| **Replications** | 4-1=3 | 42.67 | 56.26 | 49.47 | 24.66 | 14.98 | 19.82 | 116.40 | 88.62 | 102.51 |
| **Irrigation Levels (A)** | 3-1=2 | 264.18 | 312.20 | 278.19 | 201.22 | 241.51 | 221.37 | 56.80 | 91.14 | 73.97 |
| **Main Plot Error (a)** | 3x2=6 | 12.65 | 15.24 | 13.95 | 20.24 | 48.16 | 34.2 | 10.18 | 18.18 | 14.18 |
| **Cowpea Genotypes (B)** | 14-1=13 | 329.23 | 254.27 | 291.75 | 112.89 | 323.21 | 218.05 | 197.25 | 142.55 | 169.9 |
| **A x B** | 2x13=26 | 108.56 | 95.65 | 102.11 | 17.54 | 103.56 | 60.55 | 107.88 | 74.16 | 91.02 |
| **Sub Plot Error (b)** | 3x3x13=117 | 8.98 | 18.29 | 13.64 | 4.88 | 12.82 | 8.85 | 8.13 | 10.23 | 9.18 |
| **Total** | (4x3x14)-1=167 | 746.27 | 751.91 | 749.09 | 381.43 | 744.24 | 562.84 | 496.64 | 424.88 | 460.76 |
| **Average Mean:** | | 32.44 | 35.00 | 33.72 | 6.11 | 7.23 | 6.67 | | | |
| **Analysis of Variance:** | | | | | | | | | | |
| **Phenotypic Variance ($\delta^2$p)** | | 89.04 | 77.29 | 83.17 | 31.88 | 90.42 | 61.15 | 55.41 | 43.31 | 49.36 |
| **Genotypic Variance ($\delta^2$g)** | | 80.06 | 59.00 | 69.53 | 27.00 | 77.60 | 52.30 | 47.28 | 33.08 | 40.18 |
| **Environmental Variance ($\delta^2$e)** | | 8.98 | 18.29 | 13.64 | 4.88 | 12.82 | 8.85 | 8.13 | 10.23 | 9.18 |
| **Phenotypic Coefficients of Variation (PCV %)** | | 29.09 | 25.12 | 27.05 | 92.41 | 131.52 | 117.24 | 381.73 | 284.89 | 329.84 |
| **Genotypic Coefficients of Variation (GCV %)** | | 27.58 | 21.95 | 24.73 | 85.05 | 121.84 | 108.42 | 352.62 | 248.98 | 138.46 |
| **Environmental Coefficients of Variation (ECV %)** | | 9.24 | 12.22 | 10.95 | 36.16 | 49.52 | 44.60 | 146.22 | 138.46 | 142.25 |
| **Broad Sense Heritability ($h^2_B$)** | | 89.91 | 76.33 | 83.60 | 84.96 | 85.52 | 85.53 | 85.33 | 76.38 | 81.40 |
| **Genetic Advance (GA)** | | 17.50 | 13.84 | 15.73 | 9.87 | 16.84 | 13.80 | 13.10 | 10.37 | 11.38 |
| **Genetic Advance as Percentage of Mean (GAM)** | | 53.96 | 39.55 | 46.64 | 161.47 | 232.85 | 206.86 | 671.97 | 448.91 | 553.91 |

Accordingly, the high and moderate estimated of PCV% and GCV% for relevant abovementioned traits indicated that, the genotype could be reflected by the phenotype and the effectiveness of selection based on the phenotypic performance for these characters in any future cowpea breeding program under used martial's.

Broad sense heritability estimates ($h^2_B$) indicated high values (> 60, according to Robinson *et al*., 1949) for dry matter percent (Table 15), expected forage fresh and dry yields / fad (Table 16) and water use efficiency (Table 17).

Low broad sense heritability indicates predominance of non-additive gene action indicated the scope for breeding as is evident. Also, high broad sense heritability was coupled with high genetic advance as percent of mean observed for dry matter percent, expected forage fresh and dry yields/fad and water use efficiency (Tables 15, 16 and 17); indicated that most likely the heritability of these characters was due to additive gene effects and selection might be effective for these characters. On the other hand; the variations of the heritability values and genetic advances were found to be independent for some cases under study, thereby reflecting that high heritability was not always associated with high genetic advance.

High heritability coupled with low genetic advance indicates non-additive gene action. The heritability exhibited due to favorable influence of environment rather than genotypes and selection for such traits may not be rewarding. If, low heritability coupled with low genetic advance indicates such character was highly influenced by environment and selection would be ineffective for that traits. Therefore, the used genetic materials offer positive opportunities for improving the productivity of cowpea populations as a primary and main objective of this study. High heritability estimate indicates less influence of environment on respective characters. Hence, direct selection can be followed to improve early maturing genotypes. Low heritability (broad sense) indicates predominance of non additive gene action indicating the scope for breeding. High estimates of GA coupled with substantial amount of heritability indicate that selection for such characters would result in the improvement of characters in the desired direction as the character is governed by additive genes. High heritability coupled with low genetic advance indicates non-additive gene action.

The heritability exhibited due to favorable influence of environment rather than genotypes and selection for such traits may not be rewarding. If, low heritability coupled with low genetic advance indicates such character was highly influenced by environment and selection would be ineffective for those traits.

**Correlation Coefficients between Forage Yield Traits of Cowpea:**

In the present study, Phenotypic correlation coefficients for ten forage yield traits of fourteen cowpea populations affected by three irrigation levels during 2017 and 2018-seasons were estimated and summarized in Table (18). With exception of the relationship between water use efficiency trait with all forage traits under investigated during the two seasons; 2017-2018 {i.e. plant height (0.44 and 0.38; respectively), no. of shoots/plant (0.21 and 0.33; respectively), leaf / stem weight ratio (0.23 and 0.25; respectively), dry matter percent (0.38 and 0.35; respectively), forage fresh yield/plot (0.47 and 0.51; respectively), forage dry yield/plot (0.43 and 0.36; respectively), expected forage fresh yields/fad (0.67 and 0.51; respectively) and expected forage dry yields/fad (0.55 and 0.48; respectively)}.

**Table (18):** Phenotypic Correlation Coefficients for Ten Forage Yield Traits of Fourteen Cowpea Populations Affected by Three Irrigation Levels during 2017 (Above Diagonal ) and 2018-Seasons (Below Diagonal)

| Characters | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| **1. Plant Height (cm)** | | -0.56* | -0.45* | 0.55* | 0.25 | 0.18 | 0.22 | 0.56* | 0.44* |
| **2. Number of Shoots / Plt.** | -0.41* | | 0.57* | 0.38* | 0.44* | 0.23 | 0.45* | 0.33 | 0.21 |
| **3. Leaf-to-stem weight ratio** | -0.38* | 0.47* | | 0.11 | 0.20 | 0.14 | 0.24 | 0.21 | 0.23 |
| **4. Dry Matter (%)** | 0.49* | 0.28 | 0.13 | | 0.17 | 0.43* | 0.16 | 0.33 | 0.38 |
| **5. Forage Fresh Yield / Plot** | 0.31* | 0.47* | 0.21 | 0.19 | | 0.29 | 0.30* | 0.28 | 0.47* |
| **6. Forage Dry Yield / Plot** | 0.22 | 0.32* | 0.16 | 0.48* | 0.32* | | 0.46* | 0.54* | 0.43* |
| **7. Expected Fresh Yield/Fad.** | 0.25 | 0.51* | 0.27 | 0.17 | 0.35* | 0.38* | | 0.60* | 0.67* |
| **8. Expected Dry Yield/Fad.** | 0.46* | 0.29 | 0.23 | 0.41* | 0.34* | 0.47* | 0.55* | | 0.55* |
| **9. Water Use Efficiency** | 0.38* | 0.33* | 0.25 | 0.35* | 0.51* | 0.36* | 0.51* | 0.48* | |

For testing the significant of correlation coefficients, "*t*" value for n-2 at 0.05 is 0.159.

Contrarily, the plant height had negative and highly significant correlation with no. of shoots/plant and leaf/stem ratio during 2017 and 2018-seasons. The existing negative correlation above-mentioned (Table: 18) makes it difficult to perform selection in the direction of such traits. Mohamed *et al.* (2013); mentioned that, positive correlations show that as breeders change the mean of one character towards the higher side, the other also goes up with it, while, in the negative as the mean value of one character goes up, the value for the other character goes down. Consequently, the water use efficiency (WUED) had highest positive correlation with fresh and dry forage yields. Contrarily, WUED had negative and highly significant correlation with dry matter percent (DM %).

Likewise, Nath and Tajane (2014) observed highly significant positive association between green forage yield/plant with plant height (0.81), Leaf: stem ratio (0.75) and dry matter yield/plant (0.91), while, not reaching at significant level with number of branches/plant (0.07). The character dry matter yield per plant (0.91) showed highly significant and positive association with green forage yield per plant.

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# تأثير النقص المائي في مراحل النمو المختلفة على إنتاجية المحصول العلف لأربعة عشر تركيب وراثي من في لوبيا العلف

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أجريت هذه في محطة البحوث الزراعية. بمحافظة الإسماعيلية، مصر، لتقييم أربعة عشر عشيرة من للوبيا العلف، حيث تم الحصول عليها من مناطق مختلفة بما في ذلك صنف واحد مصري وذلك تحت ثلاثة مستويات من الري (١٠٠٪، ٧٥٪ و ٥٠٪ من السعة الحقلية)، لدراسة محصول العلف الأخضر، التباين الوراثي وخصائص الارتباط بين الصفات محل الدراسة خلال الموسمي الصيفين ٢٠١٧ و ٢٠١٨. وقد اتبع تصميم القطاعات الكاملة العشوائية المنشقة. أظهر تحليل التباين أن التراكيب الوراثية للوبيا العلف تحت التقييم سجلت اختلافات معنويًا (P <0.05) لطول النبات، عدد الفروع/نبات، نسبة المادة الجافة، محصول العلف الأخضر والجاف/القطعة التجريبية، والمحصول المتوقع من العلف الأخضر والمحصول الجاف طن/الفدان وكفاءة استخدام المياه}. كانت مستويات الري لها تأثيرات غير معنوية على الصفات المتبقية {أي: طول النبات، عدد الأفرع/النبات في الموسم الثاني، نسبة الأوراق/الساق، نسبة المادة الجافة، محاصيل العلف الرطب والجاف/بلوط قطعة الأرض، محصول العلف الجاف المتوقع/الفدان وكفاءة استخدام المياه}. علاوة على ذلك، فإن مستويات الري والتفاعل بين التراكيب الوراثية اللوبيا كان هناك أظهرت فروق ذات دلالة إحصائية في الصفات المدروسة، باستثناء عدد الأفرع/نبات تحت مستويات الري الثلاثة في كلا الموسمين؛ حيث كان التركيب الوراثي الكيني المسمى KF-122 أعلى الأصناف المنزرعة في كل الصفات التي تم دراستها تحت مستويات الجفاف المختلفة كما أعطي أعلي قيما لصفة البروتين الخام (٢٤.٢٠٪) وألياف خام (٢٧.٦٠٪)، بينما كان التركيب الوراثي الهندي IN-1-14 أقل التراكيب الوراثية في جميع الصفات المدروسة وأيضا في صفة البروتين الخام (١٢.٢٠٪) وصفة الألياف الخام (١٣.٩٠٪)، علاوة على ذلك، تم تسجيل التركيب الوراثي للصنف المصري المسمى "Buff" قيما متوسطة لكل الصفات التي تم دراستها في كلا الموسمين. كان معامل التباين المظهري (PCV٪) أعلى بقليل من معامل التباين الوراثى (GCV٪) لكل الصفات قيد الدراسة. أيضا أعطي معامل التوريث بالمعنى الواسع قيما متوسطة إلى مرتفعة لجميع الصفات قيد الدراسة.