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Morphological, Physiological and Chemical Traits of Some Forage Cowpea Genotypes

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Abstract: Various types of cowpea are cultivated in Egypt which might cause a tendency for nutritional and morphological variations. Thus this work was conducted at Giza Agricultural Research Station and at the laboratory of Seed Technology Research Department, Field Crops Research Institute, ARC, Giza, Egypt during the two successive seasons of 2012 and 2013 to evaluate ten promising forage cowpea genotypes and one local cultivar for their productivity and seed quality traits (description of seed cowpea genotypes, seed germination, seedling vigor, accelerated aging test, seeds diameter and chemical analysis of seed), in comparison with forage cowpea cultivar (Balady). Results showed that the genotypes varied in all forage yield, seed yield and seed quality characters. Genotype G4 was superior in forage yield (12.1 ton fed^{-1}), while genotype G7 was highest in 100-seed weight and seed yield (14.9 g and 775.6 kg fed^{-1}), respectively (one feddan = 4200 m^2). The genotypes were different in seed coat color, seed shape, hilum color and seed coat texture. The highest germination percentage (90 %) was recorded in genotype G4 while low germination percentage (62 %) was recorded in genotype G9.The lowest values of electrical conductivity test (32.3 $\mu Scm^{-1}g^{-1}$) was recorded in genotype G4. The highest value for protein was 21.9 % followed by 21.7 % and they were recorded in genotypes G4 and G10, respectively. The genotypes were different in concentration of microelements Fe, Mn, Zn and Cu. Considerable genetic distances were observed between local cultivar and promising genotypes. Different crossing programs are recommended between local and elite genotypes to develop new cowpea genotypes for forage yield, seed yield and quality. Out of the eleven genotypes under study G4, G2, G3, G8, G6, G1 and G7 were found suitable for getting higher green fodder yield whereas the genotypes G7, G4, G10, G5, G2 and G3 were found more suitable for maximum seed yield. G4 may be used both as fodder and seed crop. On the other hand, G4, G3, G2, G10, G7 and G8 could be suitable exclusively as seed quality entries under Egypt conditions.

Key words: *Vigna unguiculata* · Forage yield · Seed yield · Seed quality · Description of seed · Cluster analysis

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is one of the most important grain legume crops that grow in tropical and subtropical zones of the world, being the major source of dietary protein, calories, dietary fiber, minerals and vitamins for a large segment of world population [1]. In addition to grain, cowpea can produce good yields of fodder for ruminant feeding systems [2]. Cowpea hay is a nutritious balanced fodder for animals and has a great function in feeding animals during the dry season in West Africa [3, 4]. Cowpea can also intercropped with maize and sorghum for a higher yield and quality compared to sole cropping [5, 6]. To obtain maximum benefits from selection procedure, plant breeders must be able to identify and manipulate a combination of morphological and quality traits that positively enhance grain yield increase in cowpea. Traditionally, diversity is estimated by

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measuring variation in phenotypic or qualitative traits (flowering start, time to maturity, plant type, flower color, seed type, seed color, seed size and hilum color) and quantitative agronomic traits. However, this approach is often limited and expression of quantitative traits is subject to strong environmental influence [7].

Seed coat color is major trait that affects consumer acceptability in cowpea and seed coat color preference and use patterns differs from one region to another [8]. Drabo *et al*. [9] have shown that four genes interact to produce ten different seed coat colors; purple, black, dull black, blue, red coffee, maroon, clay, pink and white or cream in cowpea.

The pods of many cowpea varieties contains anthocyanin and are either or partially purple. Sen and Bhowal [10] suggested that three alleles at the gene locus govern pods with purple tip, green sutures. They also showed that amber-straw and the brownish straw colors of dry pods are controlled by a single gene.

Chemical composition and nutritional properties of cowpeas vary considerably according to cultivar. For effective utilization of newly developed cowpea cultivars for human nutrition, the removal or reduction of antinutrients and evaluation of their nutritional properties are necessary [11].

Thus, the aim of this investigation was to determine the differences in the morphological growth features and the variation in seed quality for ten divergent cowpea genotypes in Egypt.

MATERIALS AND METHODS

Field Work: Field experiment was conducted at Giza Agricultural Research station, ARC, Egypt, during 2012 and 2013 summer growing seasons to evaluate eleven genotypes for forage yield, seed yield and their components and seed and seeding traits including (seed germination, color seeds, seeds diameter and chemical analysis of seed). Ten genotypes (G1,..., G10) of cowpea are kindly supplied by National Gene Bank Agricultural Research Center, Giza, Egypt and one check cultivar (Balady).

Variation among genotypes was studied by growing them in a space-planted experiment in a randomized complete block design with four replications. The soil texture was clay loam, with pH 7.7 and 7.8, organic matter 0.83 and 0.80 and EC 1.86 and 1.77 dsm^{-1} in the first and second seasons, respectively. The trial was planted on 7^{th} and 12^{th} May 2012 and 2013, respectively. The experimental plots consisted of 5 ridges, each 4 m long and 60 cm wide with single-plant hills spaced 30 cm apart. Hills were over seeded then thinned to one plant/hill after complete emergence. Recommended cultural practices for cowpea production were followed. One cut was taken after 60 days from sowing then the cowpea crop was left for flowering and seed production. Ten guarded plants of each plot were chosen as a sample for measuring individual plant characters.

The following characters were studied:

Forage Yield and its Components: length of main tendril (cm), number of branches $plant^{-1}$, stem diameter (cm), number of leaves $plant^{-1}$, leaf length (cm), leaf width (cm), leaf / stem ratio (%), fresh forage yield $plant^{-1}$ (g), dry forage yield $plant^{-1}$ (g), fresh forage yield in ton fed^{-1} and dry forage yield in ton fed^{-1} (one feddan is ca. one acre).

Seed Yield and its Components: pod length (cm), pod width (cm), number of seeds pod^{-1}, number of pods $plant^{-1}$, seed weight pod^{-1}, seed weight $plant^{-1}$ (g), seed yield (kg fed^{-1}).

Laboratory Test: Laboratory tests were conducted at Seed Technology Research Department, ARC, Giza, Egypt. Laboratory experiment was laid out in a randomized compete block design with four replicates to estimate seed quality traits:

Description of Seed Cowpea Genotypes: The properties of the cowpea seeds, namely seed coat color, seed shape, hilum color and seed coat texture were described as explained according to Ogle *et al.* [12].

Seed Vigor

Germination Capacity: germination capacity was determined according to the methods outlined in procedures for seed testing [13]. Four replicates of 50 seeds were planted in boxes of (40 x 20 x 20 cm) dimension containing sterilized sandy soil. The boxes were then watered and kept at 25°C in the germination chamber for 8 days.

Fresh and Dry Seedling Weight (g): at the final account of the germination test ten normal seedlings from each replicate were taken to measure the shoot and radical length (cm). Ten seedlings dried in hot-air oven at 70 °C for 12 hours were weighed to estimate seedling dry weight (g) according to Krishnasamy and Seshu [14].

Electrical Conductivity Test (μScm^{-1} g^{-1}): the electrical conductivity of the leachate was determined according to procedures described by AOSA [15]. Four sub-samples of 50 seeds of each treatment were weighed, placed into flask with 250 ml of distilled water and held at 25°C for 24h. The electrical conductivity of the leachates was determined using conductivity meter.

Germination Index: germination index was calculated using the following formula [16]:

$$\text{Germination index} = \frac{\text{Number of seeds germinated (1}^{st}\text{ count)}}{\text{Number of days to first count}} + \frac{\text{Number of seeds germinated (last count)}}{\text{Number of days to last count}}$$

Seedling Vigor Index: seedling vigor index was determined according to the formula given by Reddy and Khan [17]:

Seedling vigor index (1) = Seedling length (cm) X Germination%
Seedling vigor index (2) = Seedling dry weight (g) X Germination%

100-seed Weight (g): according to ISTA [13].
Seed diameter (mm).

Accelerated Aging Test: The seeds were kept in an aging chamber at 42°C and 100 % relative humidity for 72 hours. After ageing, seeds were taken out of the aging box and subjected to standard germination test at 25°C according to AOSA [15].

Seed Chemical Analysis: nitrogen percentage was determined by using micro kjeldahl methods and crude protein percentage was estimated by multiplying the nitrogen percentage by 6.25; also total carbohydrates, fiber and some microelements (Fe, Zn, Mn and Cu) were determined according to AOAC [18].

Statistical Analysis: The obtained data were statistically analyzed according to procedures outlined by Steel *et al.* [19] using the computer program PLABSTAT [20]. Means were compared by least significant differences (LSD) at 5% level. Bartlett's test was done to detect the homogeneity of error variances. The test was non significant for all traits, thus combined analysis across the two seasons was carried out for all studied traits.

Dendrogram was generated by using perceptual mapping (PERMAP) using SYSTAT version 7.0 [21].

RESULTS AND DISCUSSION

Forage Yield and its Components: Mean values of forage yield per plant and related characteristics for 11 cowpea genotypes from the combined analysis across seasons are presented in Table (1). Analysis of variance showed significant differences among genotypes in all traits. The results in Table (1) showed that the genotype G 4 was superior in length of main tendril, number of branches, stem diameter, number of leaves, leaf length, leaf width, leaf/stem ratio, fresh and dry forage yield plant^{-1}, recording the values 158.3 cm, 8.2, 0.92 cm, 51.2, 29.0 cm, 19.8 cm, 122.1%, 346.2 g and 50.9 g, respectively.

While the lowest values 90.3 cm, 4.7, 0.52 cm, 35.0, 18.1 cm, 14.3 cm, 140.8g and 20.1g for the same characters, respectively, except leaf/stem ratio (138.9%) were recorded with genotype G10. Magashi *et al.* [22] observed large variability for plant height, number of leaves and number of branches.

Means of the tested cowpea genotypes for total fresh and dry forage yields (ton fed^{-1}) and their relative yield compared to check variety (Balady) across the two seasons are presented in Table (2).

Results in Table (2) showed significant differences among genotypes in total fresh and dry forage yields. The promising genotype G4 produced the highest total fresh and dry forage yields (12.1 and 1.8 ton fed^{-1}), respectively and exceeded the check cultivar (Balady) by (40.8 and 47.1%), respectively. Meanwhile, genotype G10 produced the lowest total fresh and dry forage yields (3.9 and 0.6 ton fed^{-1}), respectively and it was less than the check cultivar (55.0 and 53.4%), respectively. Sharawy and El-Fiky [23] found that significant differences among yield traits can be used to identify the different genotypes.

Seed Yield and its Components: Results in Table (3) show that pod length (cm), pod width (cm), number of seeds pod^{-1}, number of pods plant^{-1}, seed weight pod^{-1}, seed weight plant^{-1} (g), seed yield (kg fed^{-1}) and relative yield were significant differences among genotypes. The highest values were 15.9 cm, 0.7 cm and 15.5 for pod length, pod width and number of seed pod^{-1} recorded in genotype G4. Meanwhile the lowest values 10.7 cm, 0.6 cm and 10.4 recorded in genotype G9 for the same characters. Genotype G7 gave the highest values of 24.5, 1.22 g, 22.2 g and 775.6 kg fed^{-1} for number of pods plant^{-1}, seed weight pod^{-1}, seed weight plant^{-1} and seed yield, respectively and exceeded the check cultivar (Balady) by (85.2%). Increasing major components of grain yield such

Table 1: Mean values of forage yield and related characteristics for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Length of main tendril (cm)	Number of branches plant^{-1}	Stem diameter (cm)	Number of leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)	Leaf/stem ratio (%)	Fresh forage yield plant^{-1} (g)	Dry forage yield plant^{-1} (g)
G1	125.0	5.3	0.83	33.8	23.9	17.1	107.3	300.3	36.7
G2	135.8	5.0	0.87	45.0	24.5	16.8	121.7	339.0	47.3
G3	114.7	5.3	0.80	34.7	22.9	17.2	112.9	335.6	47.0
G4	158.3	8.2	0.92	51.2	29.0	19.8	122.1	346.2	50.9
G5	96.7	5.0	0.60	24.7	19.2	16.3	146.8	217.5	30.9
G6	131.1	4.4	0.85	44.6	25.9	16.8	106.9	312.0	39.5
G7	134.2	6.2	0.73	33.0	21.1	14.8	119.8	278.6	35.4
G8	139.9	6.8	0.88	28.3	28.0	19.5	94.0	342.5	48.2
G9	118.3	3.3	0.53	26.3	18.3	15.3	116.1	178.3	25.8
G10	90.3	4.7	0.52	35.0	18.1	14.3	138.9	140.8	20.1
Check cultivar	106.3	4.7	0.63	29.7	20.3	14.6	135.1	246.0	34.6
Mean	122.8	5.4	0.74	35.1	22.8	16.6	120.1	276.1	37.9
LSD at 0.05	23.41	1.35	0.11	4.53	1.05	0.23	40.24	104.51	12.09

Table 2: Mean total fresh and dry forage yields for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Total fresh forage yield (ton fed^{-1})	*Relative yield (%)	Total dry forage yield (ton fed^{-1})	*Relative yield (%)
G1	9.9	114.9	1.4	114.1
G2	11.7	136.4	1.6	135.7
G3	9.3	107.5	1.3	106.0
G4	12.1	140.8	1.8	147.1
G5	7.6	88.4	1.1	89.3
G6	9.8	113.3	1.3	110.7
G7	10.9	126.9	1.6	131.1
G8	11.9	137.8	1.7	136.4
G9	5.5	64.4	0.8	68.7
G10	3.9	45.0	0.6	46.6
Check cultivar	8.6	100.0	1.2	100.0
Mean	9.2		1.3	
LSD at 0.05	3.66		0.42	

*The relative total fresh and dry forage yields were computed for a genotype as a percentage from the check cultivar (Balady).

Table 3: Mean values of seed yield and related characters for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Pod length (cm)	Pod width (cm)	Number of seeds pod^{-1}	Number of pods plant^{-1}	Seed weight pod^{-1} (g)	Seed weight plant^{-1} (g)	Seed yield (kg fed^{-1})	*Relative yield %
G1	10.9	0.7	11.0	12.0	0.91	10.9	382.8	91.4
G2	14.3	0.7	15.8	16.7	1.01	16.9	591.0	141.1
G3	11.2	0.5	13.8	18.0	0.93	16.8	588.5	140.5
G4	15.9	0.7	15.5	21.2	1.16	20.4	715.4	170.8
G5	12.8	0.7	13.0	15.7	1.14	17.9	626.3	149.5
G6	10.4	0.5	10.5	16.3	0.72	11.8	412.0	98.4
G7	12.1	0.7	12.2	24.5	1.22	22.2	775.6	185.2
G8	11.5	0.6	10.6	12.7	0.88	11.3	393.8	94.0
G9	10.7	0.6	10.4	13.0	0.79	10.3	360.0	86.0
G10	15.0	0.7	13.9	20.5	0.97	19.6	684.8	163.5
Check cultivar	11.6	0.6	11.3	13.3	0.91	12.0	418.8	100.0
Mean	12.4	0.6	12.5	16.7	0.97	15.5	540.8	
LSD at 0.05	1.53	0.06	1.51	2.09	0.20	1.57	67.16	

*The relative total fresh and dry forage yields were computed for a genotype as a percentage from the check cultivar (Balady).

as pods plant^{-1}, pod length, seed pod^{-1}and seed size could allow improving cowpea yield potential. The variability of these morphological traits has been reported by different authors, as Mishra *et al.* [24], Carnide *et al.* [25] and Magashi *et al.* [22].

Results in Table (4) show that the genotypes were different at seed colour, seed shape, hium color and seed coat texture. These results are in accordance with the finding of Drabo *et al*. [9]. The genotypes were different in seed coat color between black to cream. Seed coat color

Table 4: Description of seed for 11 cowpea genotypes

Genotype	Seed coat color	Seed shape	Hilum color	Seed coat texture
G1	Red	Rectangular	White	Smooth
G2	Cream	Square	White	Smooth
G3	Buff	Rectangular	White	Rough
G4	Cream	Square	White	Smooth
G5	Cream	Globose	Black	Smooth
G6	Cream with black point	Rectangular	Black	Rough
G7	Black	Kidney	Black	Smooth
G8	Light brown	Square	White	Smooth
G9	Dark brown	Square	White	Smooth
G10	Cream	Rectangular	White	Smooth
Check cultivar	Buff	Kidney	White	Rough

Table 5: Seed vigor and 100-seed weight for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Germination (%)	Germination index	Seedling vigor index (1)	Seedling vigor index (2)	100-seed weight (g)
G1	82.0	15.6	1249.6	7.3	11.7
G2	82.0	20.8	1871.0	6.5	13.9
G3	81.0	7.1	1901.0	5.5	11.5
G4	90.0	19.5	2430.6	9.9	14.8
G5	71.0	5.4	1631.0	6.9	10.9
G6	72.0	7.2	1429.0	5.7	10.8
G7	83.0	15.8	1745.0	7.4	14.9
G8	73.0	17.5	1744.3	7.3	11.8
G9	62.0	7.4	752.0	0.6	10.5
G10	87.0	10.1	1792.0	5.9	14.1
Check cultivar	72.0	10.1	1634.3	6.4	12.3
Mean	77.7	12.4	1652.7	6.3	12.5
LSD at 0.05	2.24	0.48	1.49	0.04	1.24

is a major trait that affects consumer acceptability of newly released genotypes. The seed color preference and use pattern differs from one region to another [8]. Nwofia [26] showed that all color genes could be recessive to give red seeds while the absence of seed coat pigmentation results in cream or white seeds. Results show that seed texture ranged from smooth to rough.

Additionally, the results from Nkouannessi [27] study showed that seed texture ranged from rough to wrinkle. Smooth to rough seed texture were reported in accession evaluation by Adewale *et al*. [28].

A significant (P ≤ 0.05) difference was observed among all 11 genotypes in Table (5). For the characters, germination percentage, germination index, seedling vigor index (1) and (2) and 100-seed weight were significantly different among genotypes. Olufajo and Singh [29] reported that cowpea germinated epigeally (on the surface) and that first leaves above that surface of the soil are simple and opposite where subsequent trifoliate leaves are alternate and seedling have large leaves and provide canopy. The highest seed germination (90%) was recorded in genotype G4 followed by (87%) in genotype G10 compared with check cultivar (72%).

The cowpea cultivars with high germination percentage showed higher sucrose, raffinose and difference in germination capacity may be related to inhibition of genes that control the composition differences [30]. Magashi *et al*. [22] reported that the varieties were different at germination percentage. Xu *et al.* [31] indicated that during germination, seed has a dual role: frist as a source of sucrose produced in cotyledons and second as sink when the young seedling uses sucrose for development. The low germination percentage (62%) was observed in genotype G9. The low germination may be due to the immature seeds. Besides germinated seed was lowest in N2 Carbon source in cells of higher plants to support as energy resources [31].Genotypes G7and G2 gave (83%and 82%) germination percentage. The germination index values ranged from 20.8 to 5.4. The highest value (20.8) was recorded in genotype G2 followed by (19.5) in genotype G4. The lowest value (5.4) was observed in genotype G5 compared with check cultivar (10.1). For seedling vigor index (1) and (2), the highest values (2430.6 and 9.9) were recorded in genotype G4 while the lowest values (752.0 and 0.6) were recorded in genotype G9.

Table 6: Accelerated aging germination (%), Electrical Conductivity and seedling characters for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Accelerated aging germination (%)	Electrical Conductivity (μscm-^{1}g^{-1})	Diameter of seeds (mm)	Shoot length(cm)	Radical Length(cm)	Fresh weight of seedling (g)	Dry Weight of seedling (g)
G1	60.0	40.4	0.52	11.7	3.9	3.3	0.09
G2	59.0	41.2	0.53	19.4	4.2	5.4	0.08
G3	59.0	38.1	0.40	19.3	4.3	3.7	0.07
G4	66.0	32.3	0.55	23.0	4.9	6.5	0.11
G5	54.0	47.3	0.47	19.3	4.5	5.0	0.09
G6	54.0	46.2	0.36	14.3	5.3	3.4	0.08
G7	60.0	37.2	0.57	17.4	3.7	4.2	0.09
G8	53.0	45.2	0.57	21.3	3.8	5.2	0.10
G9	30.0	60.4	0.57	10.0	2.1	2.1	0.01
G10	63.0	34.5	0.50	16.6	4.1	4.2	0.08
Check cultivar	55.0	47.3	0.47	19.3	4.1	4.4	0.09
Mean	55.7	42.7	0.50	17.4	4.1	4.3	0.08
LSD at 0.05	0.60	0.31	0.06	0.40	0.10	0.08	n.s

n.s= non significant.

The genotypes were different in 100-seed weight. The highest values (14.9 and 14.8 g) were recorded in G7 and G4 genotypes followed by (14.1g) in G10. This result is in agreement with that of Magashi *et al*. [22]. While the lowest values (10.5, 10.8 and 10.9 g) were recorded in G9, G6 and G5) genotypes compared with check cultivar (12.3 g). Khan *et al.* [32] found highly significant variation for 100 seed weight among 24 exotic cowpea genotypes.

Data in Table (6) revealed highly significant differences among cowpea genotypes in terms of accelerated aging test, electrical conductivity (EC), diameter of seeds, shoot and radical length and fresh weight of seedling. While for dry weight of seedling genotypes were not significantly different. Seedling vigor could be considered as an important component of quality control programs. Accelerated aging is a possible option in this process [33].

A high reduction in germination after accelerated aging was observed in cowpea seeds. Genotypes ranged from (66.0 to 30.0). The best value (66.0) was recorded in genotype G4 followed by (63.0) that recorded in genotype G10. Seeds were tested for germination and moisture content before and after aging. The best condition to evaluate physiological potential of cowpea seeds was the combination 42C°/ 48 hours [33].While the lowest value (30.0) was recorded in genotype G9 compared with check cultivar (55.0). Warna *et al.* [34] found that Black–seeded type showed the greatest insensitivity to aging flowed by Brown and White type. Electrical conductivity (EC) is an important test to predict field emergence potential of white seeded cowpea genotype in field conditions [35]. Kumar *et al*. [36] reported that EC of *Vigna radita* (L.) wilezek seed exudates significantly correlated with final stand maturity and EC and accelerated aging test were most important for predicting field emergence. Data show variation in EC value of genotypes. The values ranged from 60.4 to 32.3, the lowest value 32.3 was recorded in genotype G4, followed by 34.5 recorded in genotype G10 compared with check cultivar (47.3). Natarajaratnam *et al.* [37] found that EC of seed leachates was negatively correlated with high yield, seed leachates from low- yielding genotypes contained most sugars and free amino *ac*ids. It is suggested that suitable selection criteria for increasing yield would be EC and a vigor index based on shoot: root ratio and total dry matter 8 days after germination. Diameter of seeds ranged from 0.36mm to 0.57mm. The highest values (0.57mm), (0.57mm) and (0. 57mm) were recorded in genotypes (G7, G8 and G9), respectively, while the lowest value (0.36mm) was recorded in genotype G6. Shoot and radical length ranged from 23.0 cm and 5.3 cm to 10.0 cm and 2.1 cm, respectively. The highest values (23.0 cm and 5.3 cm) were recorded in genotype G4 and G6 for shoot and radical length, respectively. The lowest values (10.0 cm and 2.1cm) were recorded in genotype G9 for the two characters, respectively. Magashi *et al*. [22] showed that varieties were different at root length. Fresh weight of seedling ranged from 6.5g to 2.1g. The highest values (6.5 g) followed by (5.4 g) were recorded in genotype G4 and G2, respectively. The lowest value (2.1g) was recorded in genotype G9.

Data in Table (7) show that for protein, carbohydrate, fiber % and some microelements (Fe, Zn, Mn and Cu) were significantly different among genotypes.

asconcelos *et al*. [38] reported the importance of chemical and nutritional monitoring of cowpea cultivars. The protein and carbohydrate % in cowpea were higher. Cowpea seed protein content ranged from 21% to 30%

Table 7: Protein, carbohydrate, fiber % and some microelements in seeds for 11 cowpea genotypes (combined across 2012 and 2013 seasons)

Genotype	Crude protein %	Carbohydrate %	Fiber %	Fe (mg/kg)	Zn(mg/kg)	Mn(mg/kg)	Cu (mg/kg)
G1	19.8	66.5	1.1	212.7	36.0	116.7	4.8
G2	19.9	67.4	1.2	215.7	36.3	118.6	4.8
G3	21.4	67.8	1.4	202.4	39.9	114.7	5.6
G4	21.9	69.9	1.3	213.6	41.4	119.4	5.5
G5	20.5	69.3	1.4	212.6	40.5	115.7	6.1
G6	20.8	68.6	1.3	202.7	39.6	112.3	4.3
G7	20.5	67.8	1.3	207.5	37.7	112.7	4.2
G8	21.5	69.5	1.4	219.4	38.5	116.3	5.6
G9	19.6	66.8	1.2	210.7	41.2	118.3	4.8
G10	21.7	69.5	1.4	221.3	39.8	119.5	6.2
Check cultivar	19.6	65.2	1.3	200.2	39.6	119.6	6.0
Mean	20.7	68.0	1.3	210.8	39.1	116.7	5.3
LSD at 0.05	0.14	0.19	0.10	0.11	0.17	0.07	0.14

[39]. Besides, Stantos *et al*. [40] reported that they found cowpea lines with protein content as a high as 34%. The highest values for protein (21.9%) followed by (21.7%) were recorded in genotypes G4 and 10 compared with check cultivar (19.6%), while the lowest value (19.1%) recorded in genotype G9. Sebetha *et al*. [41] showed that cowpea crude protein differs by sites due to differences in soil, type and weather conditions. On the other hand, the highest values of carbohydrate (69.9% and 69.5%) were recorded in genotypes G4 and G10.While the lowest value (66.5%) was recorded in genotypes G1 compared with check cultivar (65.1%). Shahidual *et al*. [30] found that sugar composition was higher in the cultivars with high percent germination and reduced in the cultivar with lower percent germination. Furthermore, the results of protein and carbohydrate content in the present study are in good agreement with those reported previously by Abdelatief and El-Jasser [42]. Hence the breeding program can use genotypes G4 and G10 to improve upon the seed protein content of cowpea genotypes, such strategy to improve the nutritional levels of communities in cowpea growing area and also provide protein raw materials for agro-processing. The highest fiber (1.4, 1.4 and 1.4%) was recorded in genotypes G5, G8 and G10. The lowest value (1.1%) was recorded in genotype G1. For microelements, the high concentration of Fe and Zn (221.2 and 41.4) were recorded in genotypes G10 and G4, respectively. While the low concentration, (202.4 and 36.0) were recorded in genotypes G3 and G1, respectively. Concerning Mn and Cu, the high concentration (119.5 and 6.2) were recorded in genotypes G10, while the lowest concentrations (112.3 and 4.2) were recorded in genotypes G6 and G7, respectively. Micro-nutrients like Fe, Zn and Mn are known as essential minor-elements for plant growth and productivity by playing an important functional role in the physiological process. Their deficiency is considered to be the main factors for limiting yield in many areas. The main role of Zn in plant metabolism is to activate a series of enzymes. Its deficiency restricts RNA synthesis which in turn inhibits protein synthesis causing poor content of protein [43].

Cluster Analysis: Measurement of genetic distance should be very important for breeding when it is based on a broad range of traits relevant to breeding objectives. Cluster analysis for investigated traits showed diversity among investigated cowpea genotypes. A dendrogram showing the relationships among the 11 cowpea genotypes according to the forage yield and its components is illustrated in Fig (1).

The average linkage procedure [44] grouped the studied 11 cowpea genotypes into two main clusters at distance (41.858). The first cluster group includes four genotypes, whereas the second cluster comprises the rest (seven genotypes). The mean performance of the second

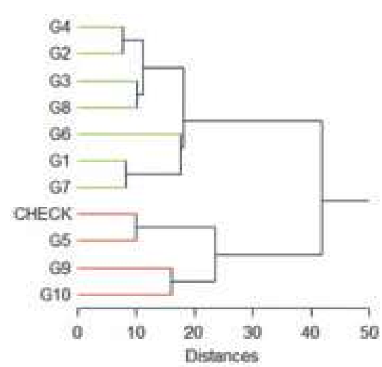

Figure 1: Dendrogram denomstrating the relationshpis among 11 cowpea genotypes based on their forage yield and its components.

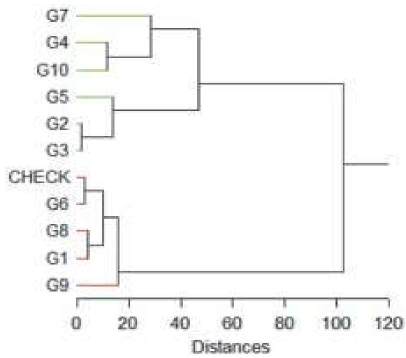

Figure 2: Dendrogram denomstrating the relationshpis among eleven cowpea genotypes based on their seed yield and its components.

cluster recorded 134.14cm, 5.90, 0.84 cm, 38.66, 25.04cm, 17.44cm, 105.67%, 322.02 g,43.57g, 10.79 ton fed^{-1}and 1.52 ton fed^{-1} for length of main tendril, number of branches plant^{-1}, stem diameter, number of leaves plant^{-1}, leaf length, leaf width, leaf /stem ratio, fresh and dry forage yield plant^{-1}, total fresh and dry forage yield per feddan, respectively. However, the corresponding mean performance of the first cluster were 102.92cm, 4.42, 0.57 cm, 28.92, 18.99 cm, 15.14 cm, 134.21%, 195.63 g, 27.86 g, 6.41 ton fed^{-1} and 0.92 ton fed^{-1} for traits in the same order. Therefore, the second cluster of genotypes exhibited superior performance for forage yield than the first cluster. On the other hand, a dendrogram showing the relationship among genotypes based on seed yeild and its components is illustrated in Fig (2). The first group was divided into two sub-groups (102.185); the first sub-groups comprised G9, G1, G8, G6 and check cultivar which recorded the lowest values for seed yield and its components. Meanwhile, the second group is devided into two subgroup clusters at distance contains G3, G2, G5, G10, G4 and G7 recorded the highest values for the same traits. A dendrogram demonstrating the relationship among genotypes under study based on the seed quality

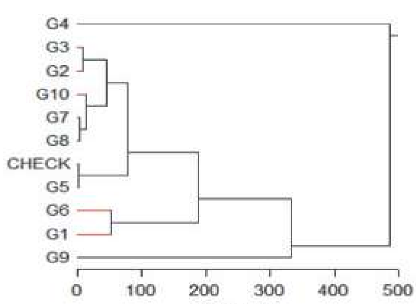

Fig. 3. Dendrogram denomstrating the relationshpis among eleven cowpea genotypes based on their seed quality.

is shown in Figure (3). The dendrogram composed of two main groups at distance (286.266). First group involves G9 only. The second one is divided into two subgroups, one of them containing G9 only while the other one is divided into two each contained 2 genotypes. In Figure (3), there is no significant distance between G5 and the check cultivar for characters under study. It seems that these genotypes need more analysis at the molecular level.

In conclusion, the present investigation indicated that there is some range of variability in cowpea. Out of the eleven genotypes under study G4, G2, G3, G8, G6, G1 and G7 were found suitable for getting higher green fodder yield, whereas the genotypes G7, G4, G10, G5, G2 and G3 were found more suitable for maximum seed yield. G4 may be used both as fodder and seed crop. On the other hand, G4, G3, G2, G10, G7 and G8 could be suitable, exclusively, as seed quality entries under Egypt conditions.

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