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EFFECT OF UNIHUMIC AND AMINOMORE ON COWPEA PLANTS (*Vigna unguiculata* L.) GROWN UNDER DROUGHT STRESS CONDITIONS

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ABSTRACT: Two pot experiments were carried out during two summer seasons of 2015 and 2016 in the screen house, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt to study the effect of foliar spraying with unihumic and/or aminomore on growth, certain physiological aspects, as well as yield and its components. Leaf anatomical features of Tepa cowpea cultivar grown under 20%, 40% and 60% water holding capacity (WHC) were also evaluated. The results revealed that drought stress at either 40% or 20% of WHC significantly decreased all growth characters studied [plant height (cm), leaf area (cm^2), number of branches/plant and dry weight of whole plant (g)]. Photosynthetic pigments and carbohydrate fractions in the leaves, as well as yield and its components [number of pods/plant, number of seeds/pod, 100-seed weight, seed weight/plant (g) and carbohydrate fractions as well as protein in seeds] were also decreased. Spraying of unihumic and/or aminomore significantly increased all these parameters. With respect to leaf anatomical features, results indicated that drought stress at either 40% or 20% of WHC reduced lamina thickness of leaflet blade, thickness of palisade tissue, spongy tissue, upper and lower epidermis, size of midvein bundle (in length and in width), number of xylem vessels/midvein bundle and the mean diameter of vessel. However, foliar spraying with unihumic and/or aminomore enhanced leaf anatomical features, except slight reduction in thickness of lamina, palisade tissue and lower epidermis. The best result was attained when cowpea plants were grown under 60% of WHC and sprayed with the combination of both unihumic and aminomore. Foliar spraying of unihumic or aminomore alleviated the adverse effect of drought.

Key words: Cowpea plants, drought stress, unihumic and aminomore foliar spraying, growth and physiological characters, anatomical features, yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an essential legume mostly grown in arid and semi-arid tropical regions. The cultivated area of cowpea plants in Egypt occupied about 4600 fad., with a total production of approximately 7104 ton according to **FAO (2017)**. Cowpea is a good source of relative inexpensive dietary protein for poor people in less developed countries. It contains about 25% proteins that easily digestible and 64% carbohydrate **(Odedeji and Oyeleke, 2011).**

Drought is an important abiotic factor that affecting physiological aspects and limiting crop yield **(Abayomi and Abidoye, 2009)**. Although cowpea is considered relatively drought tolerant, it has been shown that drought leads to a reduction in cell division rate and elongation, leaf size, stem expansion, stomatal opening, water use efficiency and alternation in various essential physiological and biochemical processes that affect growth and productivity **(Costa *et al.*, 2008)**. Drought stress reduced leaf area, leaf relative water content and seed yield of cowpea **(Hayatu *et al.*, 2014).**

Humic acid increases plant growth through chelating different nutrients. It has useful effect on growth, enhances production and improves quality of agricultural products due to having

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hormonal compounds. Humic acid foliar spray has remarkable effects on vegetative growth, increases photosynthetic activity, total leaf area, leaf area index and total dry weight **(Meena *et al*., 2018)**

Amino acids are a well-known bio-stimulant which has positive effects on plant growth, yield, enhance photosynthesis, root mass, promote nutrient absorption and essential metabolic activities in the plant. In addition it significantly mitigates the injuries caused by abiotic stresses **(Moraditochaee *et al.*, 2012)**. Amino acids application as foliar spray significantly improved shoot length, fresh and dry weight of shoots, photosynthetic pigments, total carbohydrates and polysaccharides in faba bean leaves **(Sadak *et al*., 2015).**

Therefore, this study aimed to evaluate the effects of foliar spraying with either unihumic or aminomore and their combination on growth, certain physiological aspects, as well as yield and its components. Leaf anatomical features of Tepa cowpea cultivar grown under different levels of water regimes (20%, 40% and 60% of WHC) were also examined.

MATERIALS AND METHODS

Two pot experiments were carried out during two summer seasons of 2015 and 2016 in screen house, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt. Seeds of cowpea cv. Tepa were obtained from Hort. Res. Inst., Agric. Res. Center Egypt. Seeds were planted in plastic pots (40 cm diameter) on 26 March in both seasons. Mechanical and chemical analyses of the experimental soil are shown in Table 1.

Every pot was filled with 20 kg of sandy clay soil and planted with eight seeds at equal distance and depth. After 15 days from sowing seedlings were thinned and four seedlings per pot were left. Recommended agricultural practices were applied as follow: Phosphor fertilizer (Calcium super phosphate, 15.5% P_2O_5) was mixed with the soil before sowing at the rate of 2.14 g P_2O_5/pot. After 21 days from planting, Potassium (Potassium sulfate, 48% K_2O) and Nitrogen (Urea, 46.5% N) were added at the rate of 0.54 g K_2O/pot and 1.07 g N/pot, respectively. While, the same doses of K_2O and N/pot were added after 45 days from planting.

Experimental Conditions

Cowpea cv. Tepa was subjected to the three levels of water stress as follow: W_1: Well-watered (control) *i.e.* 60% of water holding capacity (WHC), which was adequate for optimum cowpea plant growth from planting to maturity; W_2: Moderate water stress 40% of WHC after two weeks from planting to maturity and W_3: Severe water stress 20% of WHC after two weeks from planting to maturity.

After 20, 35 and 50 days from sowing, the plants were sprayed with each of tap water (control) or unihumic or aminomore as follows: F_0: Spraying plants with distilled water; F_1: Spraying plants with unihumic (1.5 ml/l); F_2: Spraying plants with aminomore (1 ml/l) and F_3: Spraying plants with the combination between unihumic and aminomore.

The commercial product unihumic was used as a source of humic acid. Unihumic contained humic acid (18.5%), fulvic acid (4%), K_2O (1.5%), chelated Fe (1000 ppm), chelated Zn (500 ppm) and chelated Mn (500 ppm). The recommended dose (1.5 ml/l) of unihumic was added as foliar application after 20, 35 and 50 days from sowing. Whereas, the commercial product aminomore was used as a source of amino acids which comprised lysine (0.64%), histidine (0.21%), argenine (1.75%), proline (1.48%), phenylalanine (0.37%), tyrosine (0.19%), total amino acid (15.78%), K_2O (10%) and chelated Fe (1000 ppm), chelated Zn (500 ppm) and chelated Mn (500 ppm). The two products were obtained from union for agricultural development company.

Samples were uprooted from each pot at 45 days carefully after 10 days from the second spraying and then, separated into root, stem and leaves to measure growth and physiological characteristics as well as leaf anatomy.

Measurements

Growth characteristics

Plant height (cm), leaf area (cm^2), number of branches per plant and dry weight of whole plant (g) were determined as growth characteristics. The dry weight was estimated by drying plant organs in electric oven at 70°C until constant weight **(AOAC, 1995)**.

Table 1. Mechanical and chemical analyses of the experimental soil

Soil texture	Mechanical analysis			Chemical analysis													
	Soil fractions (%)			Soluble cations (mg/l)				Soluble anion (mg/l)				Ec, ds/m (mmhos /cm)	Organic matter (%)	pH	N, mg/l	P, mg/l	K, mg/l
	Sand	Silt	Clay	Ca^{++}	Mg^{++}	Na^{++}	K^{+}	Co_3^{--}	Hco_3^{-}	Cl^{-}	So_4^{--}						
Sandy clay	78.05	10.15	11.80	1.95	2.51	0.49	0.21	nil	2.23	0.52	2.40	0.52	11.0	7.82	54.10	18.7	80.4

Physiological Characteristics

Photosynthetic pigments

Photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) were extracted from fresh leaves (0.1g) by using pure acetone. Samples were filtrated and the filtrate was used to determine the photosynthetic pigments spectrophotometrically according to **Fadeel (1962)** at the wave length 662, 644, 440.5 nm for chlorophyll a, chlorophyll b and carotenoids, respectively. The pigments were calculated by Wettestein's formula **(Wettestein, 1957).**

Carbohydrate fractions

Total carbohydrates were determined in the dried samples of leaves photometrically according to **Bernfeld (1955)** and **Miller (1959).**

Total protein

Total protein was determined by multiplying total nitrogen concentration by the factor of 6.25 according to **AOAC (1995)**.

Yield Components

Yield and its components *i.e.* number of pods/plant, number of seeds/pod, weight of seeds/plant (g), weight of 100 seeds (g) as well as carbohydrate fractions and protein content in seeds were also determined.

Anatomical Features

Specimens from the terminal leaflet blade on 5th internode of the stem at the age of 45 days from planting at the second growing season (2016) were cleaned, killed and fixed in FAA, dehydrated, cleared and embedded in paraffin (melting point 56°C). Sectioning at thickness of 20 microns (μm) was performed by using a rotary microtome. Sections were stained with safranin and light green combination and then, cleared, mounted in Canada balsam and examined **(Nassar and El-Sahhar, 1998)**.

Statistical Analysis

All data were subjected to statistical analysis by complete randomized block design according to **Snedecor and Cochran (1990)**. Means separation were done by LSD at 0.05 and 0.01 levels of probability.

RESULTS AND DISCUSSION

Growth Characteristics

Plant height

Table 2 shows that drought stress significantly reduced plant height. The severe drought stress (20% of WHC) decreased plant height by 49% in the first season and 50% in the second one.

The moderate level of drought stress (40% of WHC) significantly reduced plant height of cowpea plants by 24% in both seasons as compared to the well-watered plants (control). A decline in plant height with response to drought stress might be due to reduction in cell elongation resulting from the inhibiting effect of water shortage on growth promoting hormones which in turn lead to decrease in cell turgor, volume and eventually growth and also, may be attributed to drop in leaf water content **(Abdul Qados, 2014)** and/or the blocking up of xylem and phloem vessels, hindering translocation **(Farouk and Ramadan, 2012)**.

Unihumic foliar spraying resulted in a significant increase in plant height, which might be due to the increase of permeability of plant membranes and enhance the uptake of nutrients and increasing endogenous hormone, which stimulate cell division and cell enlargement **(Bakry *et al*., 2015)**.

Table 2. Effect of unihumic and aminomore as a foliar spraying on growth characteristics of cowpea cv. Tepa grown under different levels of drought stress

Treatment		Growth characteristic							
		1st season (2015)				2nd season (2016)			
		Plant height (cm)	Leaf area (cm^2)	Number of branches per plant	Dry weight of whole plant (g)	Plant height (cm)	Leaf area (cm^2)	Number of branches per plant	Dry weight of whole plant (g)
Drought stress	**W_1**	47.78	32.55	3.18	23.33	48.48	34.48	3.58	25.24
	W_2	36.25	20.88	2.10	16.00	36.73	23.26	2.18	17.25
	W_3	24.13	11.12	1.08	11.02	24.93	13.81	1.18	11.85
LSD (W)	**0.05**	1.13	0.42	0.35	0.68	1.12	0.40	0.23	0.98
	0.01	1.54	0.57	0.48	0.93	1.52	0.54	0.31	1.33
Means Foliar spray	**F_0**	31.63	17.90	1.80	14.69	31.97	20.21	1.90	15.62
	F_1	34.70	20.33	2.00	15.92	34.97	22.69	2.10	17.01
	F_2	37.23	22.92	2.10	17.24	37.80	24.91	2.33	19.10
	F_3	40.63	24.90	2.57	19.28	42.10	27.59	2.90	20.71
LSD (F)	**0.05**	1.30	0.48	0.41	0.79	1.29	0.46	0.26	1.13
	0.01	1.77	0.65	0.55	1.07	1.75	0.63	0.36	1.53
W_1 60% (WHC)	**F_0**	44.60	28.50	2.70	21.13	44.70	30.67	3.00	21.72
	F_1	46.50	30.97	3.00	22.32	46.80	33.43	3.30	24.69
	F_2	48.80	34.60	3.30	23.57	49.00	35.53	4.00	26.49
	F_3	51.20	36.13	3.70	26.31	53.40	38.30	4.00	28.07
W_2 40% (WHC)	**F_0**	31.70	16.87	1.70	13.90	32.00	19.27	1.70	15.41
	F_1	34.40	19.23	2.00	15.26	34.50	22.10	2.00	15.67
	F_2	37.60	22.10	2.00	16.57	37.90	24.47	2.00	18.19
	F_3	41.30	25.30	2.70	18.29	42.50	27.20	3.00	19.71
W_3 20% (WHC)	**F_0**	18.60	8.33	1.00	9.05	19.20	10.70	1.00	9.72
	F_1	23.20	10.80	1.00	10.19	23.60	12.53	1.00	10.69
	F_2	25.30	12.07	1.00	11.58	26.50	14.73	1.00	12.63
	F_3	29.40	13.27	1.30	13.26	30.40	17.27	1.70	14.34
LSD (W*F)	**0.05**	NS	0.83	NS	NS	NS	NS	0.46	NS
	0.01	NS	1.13	NS	NS	NS	NS	NS	NS

Where: W_1: Control, 60% of water holding capacity (WHC), W_2 and W_3: Irrigation at 40 and 20% of WHC, respectively.
F_0: Spraying plants with distilled water, F_1: Spraying unihumic, F_2: Spraying aminomore and F_3: Spraying unihumic + aminomore.

Subjecting cowpea plant to aminomore as a foliar spray significantly elevated plant height under normal and drought stress conditions. The positive effect of aminomore on plant height might be due to that amino acids may play an important role in plant metabolism and protein assimilation, which is necessary for cell formation and consequently, increase plant height **(Sadak *et al*., 2015)**.

Foliar spraying cowpea plants with the combination between unihumic and aminomore significantly increased plant height under normal and drought stress conditions by 30% and 32% in the first and second seasons, respectively as compared to the untreated plants. This treatment produced the longest plants as compared to the other treatments. These results are in harmony with the findings of **Shafeek *et al.* (2016)** and **Kahraman (2017)**.

Leaf area (cm^2/plant)

Drought stress significantly reduced leaf area per plant (Table 2). The lowest values of leaf area per plant were detected at the severe drought stress (20% of WHC) treatment which decreased by 65 and 60% below the control in the first and second seasons, respectively. Leaf area per plant of cowpea was significantly reduced by 35% in the first and 32% in the second season under the level of drought stress (40% of WHC) as compared to the well-watered plants. The reduction in leaf area might be due to the inhibition of leaf formation also decreases volume of new leaf tissues, resulting in decrease of leaf area **(Abayomi and Abidoye, 2009)**.

Foliar spraying with unihumic resulted in a significant increase in leaf area per plant at both studied seasons. The simulating effect of unihumic on leaf area per plant might be due to improvement of plant growth and enhancement of photosynthetic and other metabolic activities, which led to an increase in various plant metabolites responsible for cell division and cell elongation **(Manas *et al*., 2014)**.

Spraying cowpea plants with aminomore significantly increased leaf area per plant at both seasons under normal and drought stress conditions. The positive effect of aminomore on leaf area per plant could be attributed to the effect of main component of amino acids, which are essentially required for the biosynthesis of a large variety of non-protein nitrogenous materials as pigments, vitamins, coenzymes, purine and pyrimidine bases. Also, amino acids could directly or indirectly influence the physiological activities of plant growth and development, through their regulatory effects on production of gibberellins in common bean plant tissues **(Zewail, 2014)**.

Number of branches per plant

Drought stress significantly decreased number of branches per plant (Table 2). The highest values were appeared at the control; while the lowest values were appeared at the acute drought stress (20% of WHC) treatment by 66 and 67% below the control plants in the first and second seasons, respectively. The moderate level of drought stress (40% of WHC) also reduced number of branches/plant by 34 and 39% compared to the control in the first and second seasons, respectively.

It is well known that water stress caused a multitude of biochemical, molecular and physiological changes, which affecting plant growth and development **(Boutraa, 2010)**. A reduction in plant growth in response to water stress might be due to decreases in cell elongation, inhibiting effect on growth promoting hormones, decreases in cell turgor, volume, blocking up of xylem and phloem vessels, hindering translocation and finally growth **(Banon *et al*., 2006)**.

As shown in Table 2, subjecting cowpea plants to foliar spraying with unihumic increased number of branches/plant by 11% in both seasons as compared to the untreated plants. The increasing effect of unihumic on number of branches per plant might be due to the role of humic acid as a nutrient provision, which increase the availability of nutrient elements as notified by **(Erik *et al*., 2000; El-Desuki, 2004).** Treating cowpea plant with aminomore foliar spraying significantly increased number of branches per plant under normal and drought stress conditions. The positive effect of aminomore may be due to the role of amino acids in promotion of metabolic processes which leading to stimulate growth as a result of formation a new types of enzymes, proteins and some essential vitamins **(Attoa *et al*., 2002)**. In addition, the amino acids phenylalanine is known to be involved indirectly in the synthesis of gibberellins, which play an important role in the elongation of internodes and encouraging the initiation and emergence of lateral buds, and thereby increasing number of the branches **(Taiz and Zeiger, 2002).**

Foliar spraying with a combination of unihumic and aminomore significantly increased number of branches per plant. The ameliorative effects of unihumic and aminomore on number of branches per plant may be due to the effect of humic acid in increasing root growth, nutrient uptake which reflected on promoting the accumulation of leaf mineral contents and stimulated plant growth. On the other hand, the effect of amino acids may be due to their role in synthesis of proteins in the plant and the regulatory effects of certain amino acids like phenylalanine and ornithine on plant development through their influence on gibberellins **(Yousef *et al.*, 2011).**

Dry weight of whole plant

Drought stress significantly reduced dry weight of whole plant of cowpea (Table 2). The lowest values were revealed at the sharpness drought stress (20% of WHC) treatment which decreased by 53% in both seasons. The moderate level of drought stress (40% of WHC) significantly reduced dry weight of whole plant by 31 and 32% in the first and second seasons, respectively as compared to the well-watered plants at 60% of WHC (control).

A decreasing in dry weight of whole plant under drought stress may be due to increase in abscisic acid (ABA) levels in roots, which is transported from roots to shoots where it acts in the apical region of the plant as an antagonist of the auxine and cytokinin, responsible for growth and cell division as well as inhibiting DNA synthesis **(Abdalla, 2011)**.

The same table shows that foliar spraying with unihumic showed a significant increase in dry weight of whole plant at both growing seasons. The increasing effect of unihumic on dry weight of whole plant might be due to that humic acid compounds significantly increased dry weight of roots, stems, leaves and consequently, the dry weight of whole plant could be increased.

Foliar spraying with aminomore significantly increased dry weight of whole plant at both growing seasons under normal and stressed plants. The positive effect of aminomore as a source of amino acids on dry weight of whole cowpea plants might be due to that amino acids can directly or indirectly increase the physiographic activities of the plant **(Shafeek *et al.*, 2016)**.

Foliar spraying cowpea plants with a mixture of unihumic and aminomore significantly increased dry weight of whole plant under drought stress conditions at both seasons. This treatment gave the largest value of dry weight of whole plant as compared to the other treatments. The rising effects of both unihumic and aminomore on dry weight of whole plant of cowpea might be attributed to that humic and amino acids increased the biosynthesis of osmotic solutes under drought stress and increase the accumulation of dry matter in plant body **(Abd El-Aziz *et al.*, 2015)**.

The combination between drought stress and foliar spraying with unihumic and aminomore on dry weight of whole plant was non-significant in both seasons. The highest value of dry weight of whole plant was recorded under well-watered plants at 60% WHC and foliar spraying with unihumic and aminomore. However, the lowest value of dry weight of whole plant was detected under severe drought stress at 20% WHC and untreated plants with either unihumic or aminomore.

Physiological Characteristics

Photosynthetic pigments

Significant differences with regard to photosynthetic pigments concentration were recorded due to the level of drought stress and the different treatments of unihumic and aminomore as shown in Table 3. Drought stress significantly reduced photosynthetic pigments concentration in leaves. The acute and moderate levels of drought stress significantly reduced photosynthetic pigments in leaves of cowpea plants as compared to the well-watered plants (control). Chlorophyll a, chlorophyll b and carotenoids were reduced by 28, 30 and 9% below the control, respectively under the acute level of drought stress (20% WHC) in the first

Table 3. Effect of unihumic and aminomore as a foliar spraying on photosynthetic pigments of cowpea cv. Tepa grown under different levels of drought stress

Treatment		Photosynthetic pigment					
		1st season (2015)			2nd season (2016)		
		Chlorophyll a, mg/g F. wt.	Chlorophyll b, mg/g F. wt.	Carotenoids, mg/g F. wt.	Chlorophyll a, mg/g F. wt.	Chlorophyll b, mg/g F. wt.	Carotenoids, mg/g F. wt.
Drought stress	**W_1**	1.66	0.54	1.27	1.76	0.58	1.33
	W_2	1.45	0.47	1.20	1.54	0.51	1.25
	W_3	1.19	0.38	1.16	1.27	0.43	1.17
LSD (W)	**0.05**	0.02	0.02	0.03	0.02	0.01	0.03
	0.01	0.02	0.02	0.04	0.03	0.01	0.04
Means Foliar spray	**F_0**	1.31	0.43	1.18	1.39	0.46	1.22
	F_1	1.40	0.45	1.20	1.50	0.50	1.24
	F_2	1.48	0.48	1.22	1.57	0.52	1.26
	F_3	1.53	0.50	1.23	1.63	0.54	1.28
LSD (F)	**0.05**	0.02	0.02	0.04	0.03	0.01	0.03
	0.01	0.02	0.03	NS	0.04	0.01	0.04
W_1 60% (WHC)	**F_0**	1.53	0.51	1.24	1.59	0.53	1.29
	F_1	1.64	0.53	1.27	1.73	0.56	1.31
	F_2	1.73	0.56	1.28	1.84	0.61	1.34
	F_3	1.75	0.57	1.30	1.89	0.62	1.36
W_2 40% (WHC)	**F_0**	1.36	0.43	1.18	1.47	0.49	1.23
	F_1	1.43	0.46	1.19	1.52	0.51	1.25
	F_2	1.47	0.47	1.20	1.58	0.52	1.26
	F_3	1.53	0.51	1.22	1.58	0.52	1.28
W_3 20% (WHC)	**F_0**	1.04	0.34	1.12	1.13	0.37	1.14
	F_1	1.14	0.36	1.15	1.25	0.43	1.16
	F_2	1.25	0.40	1.17	1.30	0.44	1.18
	F_3	1.31	0.42	1.18	1.41	0.48	1.21
LSD (W*F)	**0.05**	0.03	NS	NS	0.05	0.02	NS
	0.01	0.04	NS	NS	0.07	0.03	NS

Where: W_1: Control, 60% of water holding capacity (WHC), W_2 and W_3: Irrigation at 40 and 20% of WHC, respectively.
F_0: Spraying plants with distilled water, F_1: Spraying unihumic, F_2: Spraying aminomore and F_3: Spraying unihumic + aminomore.

season and by 28, 26 and 12% in the second one, respectively. However, chlorophyll a, chlorophyll b and carotenoids were reduced by 13, 13 and 6% below the control, respectively under the moderate level of drought stress (40% WHC) in the first season and by 13, 12 and 6% below the control in the second one, respectively.

In this respect, **Bacelar *et al.* (2006)** indicated that the reduction of chlorophyll content is a perfect symptom of oxidative stress resulting from drought stress, which caused degradation and deficiency of chlorophyll synthesis with changes of thylakoid membrane structure.

Foliar spraying with unihumic resulted in a significant increase in photosynthetic pigments in leaves. The ameliorative effect of unihumic might be due to the increase of chlorophyll synthesis, delayed chlorophyll degradation in the leaves, increased plant resistance to environmental stresses by stimulating growth regulators, involved in protecting the photosynthetic apparatus and consequently increasing the photosynthetic pigments **(Bakry *et al.*, 2015)**.

Aminomore significantly elevated photosynthetic pigments concentration in leaves. The positive effect of aminomore may be due to that amino acids are important in many biological molecules, such as precursors for the biosynthesis of glutamine and ornithine, which are precursors for nucleotides and polyamines and forming the parts of coenzymes **(Zewail, 2014)**.

Foliar spraying of cowpea plants with unihumic and aminomore significantly increased photosynthetic pigments in leaves under normal and drought stress conditions. This treatment produced the largest value as compared to the other treatments. The simulating effects of both unihumic and aminomore might be due to their role in growth regulation, protein biosynthesis as well as stabilizing chloroplasts thylakoid membranes and retarding chlorophyll degradation. In addition, amino acids introduced into biosynthesis of large group of nonproteinic nitrogenous compounds (pigments, vitamins, Co-enzymes, purine and pyrimidine bases) **(Hanafy *et al.*, 2010)**.

The combination between drought stress and foliar spraying of unihumic and aminomore was significant in both seasons for chlorophyll a and in the second season for chlorophyll b. However, the interaction was insignificant for chlorophyll b in the first season and carotenoids in both seasons. The highest value of photosynthetic pigments was recorded under well-watered plants and foliar spraying with unihumic and aminomore. However, the lowest value was detected under severe drought stress and untreated plants with either unihumic or aminomore.

Carbohydrate fractions

Table 4 shows that the lowest values of carbohydrate fractions were obtained at the acute drought stress treatment. Total carbohydrates, total sugars, reducing sugars and non-reducing sugars were reduced by 27, 34, 22 and 38% at level of 20% WHC in the first season, respectively and by 27, 33, 22 and 36% in the second one, respectively. The moderate level of drought stress significantly reduced carbohydrate fractions of cowpea plants as compared to the well-watered plants (control). Total carbohydrates, total sugars, reducing sugars and non-reducing sugars were reduced by 13, 15, 13 and 16% at level of 40% WHC in the first season, respectively and by 12, 15, 11 and 16% in the second season, respectively. A reduction in soluble sugars and total carbohydrates with response to drought stress might be due to the nutritional imbalance and reduced photosynthesis process **(Abdul Qados, 2014)**.

Unihumic foliar spraying resulted in a significant increase in carbohydrate fractions in leaves. The ameliorative effect of unihumic might be due to the increasing of photosynthetic efficiency which led to enhance biosynthesis of carbohydrates **(Bakry *et al.*, 2015)**.

Treated cowpea plant with aminomore significantly increased carbohydrate fractions in leaves, which may be due to that amino acids are important in many biological molecules, such as precursors for the biosynthesis of glutamine and ornithine, which are precursors for nucleotides and polyamines and forming the parts of coenzymes **(Zewail, 2014)**.

Table 4. Effect of unihumic and aminomore as a foliar spraying on carbohydrate fractions of cowpea leaves cv. Tepa grown under different levels of drought stress

Treatment		Carbohydrate fraction							
		1st season (2015)				2nd season (2016)			
		Total carbohydrates (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total carbohydrates (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
Drought stress	W_1	27.66	9.41	2.41	7.00	27.84	9.14	2.25	6.89
	W_2	24.01	8.00	2.10	5.90	24.62	7.78	2.00	5.78
	W_3	20.30	6.22	1.89	4.33	20.43	6.16	1.75	4.41
LSD (W)	0.05	0.52	0.44	0.10	0.43	0.49	0.42	0.09	0.39
	0.01	0.71	0.60	0.13	0.58	0.67	0.57	0.12	0.53
Means Foliar spray	F_0	22.89	7.36	2.02	5.35	23.09	7.12	1.90	5.21
	F_1	23.30	7.62	2.08	5.54	23.57	7.34	1.96	5.38
	F_2	24.53	8.14	2.18	5.96	24.80	7.96	2.02	5.94
	F_3	25.24	8.38	2.25	6.13	25.72	8.35	2.13	6.23
LSD (F)	0.05	0.61	0.51	0.11	0.49	0.57	0.48	0.10	0.45
	0.01	0.82	0.69	0.15	NS	0.77	0.66	0.14	0.61
W_1 60 % (WHC)	F_0	26.84	8.99	2.33	6.66	26.95	8.69	2.13	6.56
	F_1	26.95	9.08	2.35	6.73	27.15	8.69	2.19	6.50
	F_2	28.07	9.68	2.41	7.27	28.17	9.48	2.27	7.21
	F_3	28.78	9.88	2.55	7.33	29.09	9.68	2.41	7.27
W_2 40% (WHC)	F_0	22.86	7.33	1.92	5.41	23.16	7.11	1.92	5.19
	F_1	23.47	7.78	2.03	5.74	24.09	7.55	1.96	5.60
	F_2	24.50	8.30	2.21	6.09	25.21	7.97	2.01	5.96
	F_3	25.21	8.59	2.23	6.36	26.03	8.49	2.11	6.38
W_3 20% (WHC)	F_0	18.97	5.78	1.80	3.98	19.17	5.55	1.66	3.89
	F_1	19.48	6.00	1.86	4.14	19.48	5.78	1.72	4.06
	F_2	21.01	6.44	1.91	4.53	21.02	6.44	1.78	4.66
	F_3	21.73	6.66	1.97	4.69	22.04	6.88	1.86	5.03
LSD (W*F)	0.05	NS	NS	NS	NS	NS	NS	NS	NS
	0.01	NS	NS	NS	NS	NS	NS	NS	NS

Where: W_1: Control, 60% of water holding capacity (WHC), W_2 and W_3: Irrigation at 40 and 20% of WHC, respectively.
F_0: Spraying plants with distilled water, F_1: Spraying unihumic, F_2: Spraying aminomore and F_3: Spraying unihumic + aminomore.

Foliar spraying with unihumic and aminomore significantly increased carbohydrate fractions in leaves under normal and drought stress conditions. This treatment produced the largest value of carbohydrate fractions as compared to the other treatments. Foliar spraying with the combination of unihumic and aminomore elevated the contents of total carbohydrates, total sugars, reducing sugars and non-reducing sugars in cowpea leaves by 10, 14, 11 and 15% in the first season, respectively and 11, 17, 12 and 20% in the second one, respectively as compared to the untreated plants.

The combination between drought stress and the treatments of unihumic and aminomore was insignificant. The highest values were recorded under well-watered plants and foliar spraying with unihumic and aminomore. However, the lowest values were detected under severe drought stress and untreated plants with either unihumic or aminomore.

Yield

Yield components

Results in Table 5 show the effects of foliar spraying with unihumic, aminomore and their combination on yield components (number of pods/plant, number of seeds/pods, weight of seeds/plant and weight of 100 seeds) of cowpea cv. Tepa grown under different levels of drought stress. The highest values of yield components were appeared at the well-watered plants (control), while the lowest values were recorded at the acute drought stress treatment (20% WHC), which decreased yield components by 58, 46, 81 and 18%, respectively in the first season and by 57, 37, 82 and 33%, respectively in the second one. The moderate drought stress treatment (40% WHC) also decreased yield components by 28, 23, 51 and 10%, respectively in the first season and by 28, 23, 52 and 13%, respectively in the second one. A decline in yield components as response to drought stress might be attributed to stomatal closure, decreased transpiration and leaf turgidity, which cause a sensitivity of cowpea stomata to drought stress with a reduction in photosynthetic capacity **(Ahmed and Suliman, 2010).** Water stress reduced plant growth, therefore may have delayed and decreased appearance of nodes and so resulting in plants with fewer pods and seed numbers per plant **(Vurayai *et al.,* 2011).**

Unihumic resulted in an increase in yield components. This increment may be refered to that humic compounds enter plant cells, several biochemical changes occur in membranes and various cytoplasmic components of plant cell. Humic acid application resulted in increasing endogenous cytokinin and auxin levels which possibly leading to improve yield and its components **(Osman *et al.,* 2013)**.

Aminomore increased number of yield components under normal and drought stress conditions. This positive effect might be due to their roles in enhancing many physiological processes including nutrients uptake by roots and their metabolism in treated plants **(Hanafy *et al.,* 2010)**. Also, amino acids as organic nitrogenous compounds stimulate cell growth and acting as buffers maintaining favorable pH value within the plant cell as well as synthesizing other organic compounds **(Opik and Rolfe, 2005)**. Amino acids are fundamental ingredients in the process of protein synthesis, formation of plant tissue and chlorophyll synthesis **(El-Ghamry *et al.,* 2009)**.

Combination of foliar spraying with unihumic and aminomore increased yield components. The effects of both unihumic and aminomore on yield components of cowpea plants could be discussed on the basis that humic and amino acids conferring desiccation resistance to plant cells.

The interaction between drought stress and the treatments of unihumic and aminomore on yield components of cowpea plants was insignificant except weight of seeds/plant in both seasons, which was significant. The lowest values of yield components were detected at 20% WHC and untreated plants with either unihumic or aminomore. However, the highest values were recorded at 60% WHC and foliar spraying with unihumic and aminomore.

Chemical composition of seeds

Carbohydrates fractions

Content of carbohydrates (Table 6) was significantly decreased by increasing levels of drought stress. The highest values for carbohydrates

Table 5. Effect of unihumic and aminomore as a foliar spraying on yield and its components of cowpea cv. Tepa grown under different levels of drought stress

Treatments		1st season (2015)				2nd season (2016)			
		Number of pods/plant	Number of seeds/pod	Weight of seeds/ plant (g)	Weight of 100 seeds (g)	Number of pods/plant	Number of seeds /pod	Weight of seeds/plant (g)	Weight of 100 seeds (g)
Drought stress	W_1	9.25	9.39	15.76	18.34	9.42	9.95	17.69	19.15
	W_2	6.62	7.25	7.78	16.53	6.75	7.65	8.54	16.63
	W_3	3.88	5.04	2.92	14.98	4.08	6.23	3.20	12.83
LSD (W)	0.05	0.95	0.76	0.68	NS	0.94	0.92	0.68	2.97
	0.01	1.29	1.03	0.92	NS	1.27	1.25	0.93	4.03
Means Foliar spray	F_0	5.64	6.52	6.54	15.75	6.00	7.42	7.90	15.22
	F_1	6.01	6.92	7.54	16.29	6.55	7.55	8.94	15.78
	F_2	6.93	7.57	9.71	16.92	7.00	8.24	10.51	16.66
	F_3	5.64	6.52	6.54	15.75	7.45	8.55	11.89	17.15
LSD (F)	0.05	1.10	0.88	0.78	NS	NS	NS	0.79	NS
	0.01	1.49	NS	1.06	NS	NS	NS	1.07	NS
W_1 60 % (WHC)	F_0	8.33	8.67	12.23	17.27	8.67	9.67	15.40	18.90
	F_1	9.00	9.23	14.20	17.73	9.33	9.80	17.17	19.03
	F_2	9.67	9.67	17.33	18.77	9.67	10.13	18.43	19.10
	F_3	10.00	10.00	19.27	19.57	10.00	10.20	19.77	19.57
W_2 40% (WHC)	F_0	5.67	6.33	5.60	16.10	6.00	7.00	6.23	14.90
	F_1	6.00	6.77	6.43	16.30	6.33	7.13	6.93	15.40
	F_2	7.13	7.90	8.90	16.70	7.00	7.90	9.37	17.70
	F_3	7.67	8.00	10.20	17.03	7.67	8.57	11.63	18.50
W_3 20% (WHC)	F_0	2.93	4.57	1.80	13.87	3.33	5.60	2.07	11.87
	F_1	3.03	4.77	2.00	14.83	4.00	5.73	2.73	12.90
	F_2	4.00	5.13	2.90	15.30	4.33	6.70	3.73	13.17
	F_3	5.57	5.67	4.97	15.90	4.67	6.87	4.27	13.37
LSD (W*F)	0.05	NS	NS	1.35	NS	NS	NS	1.36	NS
	0.01	NS	NS	1.84	NS	NS	NS	NS	NS

Where: W_1: Control, 60% of water holding capacity (WHC), W_2 and W_3: Irrigation at 40 and 20% of WHC, respectively.
F_0: Spraying plants with distilled water, F_1: Spraying unihumic, F_2: Spraying aminomore and F_3: Spraying unihumic + aminomore.

Table 6. Effect of unihumic and aminomore as a foliar spraying on carbohydrate fractions and protein concentration of cowpea seeds cv. Tepa grown under different levels of drought stress

Treatment		1st season (2015)					2nd season (2016)				
		Total carbohydrates (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Protein (%)	Total carbohydrates (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Protein (%)
Drought stress	W_1	29.87	10.52	5.28	5.23	26.11	30.12	10.39	5.32	5.07	26.46
	W_2	26.36	8.82	4.34	4.48	20.31	26.87	8.53	4.35	4.18	20.56
	W_3	22.12	6.16	3.45	2.71	13.75	23.27	5.61	3.50	2.11	14.94
LSD (W)	0.05	0.54	0.60	0.14	0.59	0.42	0.84	0.61	0.12	0.62	0.54
	0.01	0.74	0.82	0.19	0.81	0.57	1.14	0.83	0.17	0.84	0.73
Means Foliar spray	F_0	24.63	7.51	4.11	3.40	17.59	25.48	7.26	4.05	3.21	18.34
	F_1	25.55	8.02	4.26	3.76	19.18	26.47	7.93	4.34	3.59	19.88
	F_2	26.57	8.87	4.43	4.44	20.82	27.02	8.34	4.47	3.87	21.42
	F_3	27.70	9.59	4.63	4.96	22.63	28.04	9.18	4.70	4.47	22.96
LSD (F)	0.05	0.63	0.69	0.16	0.68	0.48	0.97	0.71	0.14	0.71	0.62
	0.01	0.85	0.94	0.22	0.93	0.65	1.32	0.96	0.19	0.97	0.84
W_1 60% (WHC)	F_0	28.37	9.58	5.00	4.57	23.65	28.67	9.68	5.04	4.63	24.04
	F_1	29.61	10.27	5.23	5.04	25.27	29.91	10.17	5.27	4.90	25.33
	F_2	30.22	10.76	5.41	5.35	27.00	30.53	10.66	5.41	5.25	27.45
	F_3	31.26	11.45	5.49	5.96	28.52	31.36	11.06	5.57	5.48	29.02
W_2 40% (WHC)	F_0	25.01	7.85	4.14	3.71	17.83	25.93	7.88	3.98	3.90	18.36
	F_1	25.72	8.47	4.22	4.24	19.79	26.54	8.30	4.33	3.97	19.98
	F_2	26.64	9.19	4.31	4.88	20.96	26.85	8.37	4.39	3.98	21.12
	F_3	28.07	9.78	4.69	5.08	22.65	28.17	9.58	4.70	4.88	22.77
W_3 20% (WHC)	F_0	20.50	5.11	3.18	1.93	11.30	21.83	4.22	3.12	1.10	12.63
	F_1	21.32	5.33	3.34	1.99	12.48	22.96	5.33	3.43	1.91	14.34
	F_2	22.86	6.66	3.57	3.09	14.50	23.68	6.00	3.61	2.39	15.69
	F_3	23.78	7.55	3.71	3.84	16.71	24.60	6.89	3.84	3.05	17.10
LSD (W*F)	0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	0.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Where: W_1: Control, 60% of water holding capacity (WHC), W_2 and W_3: Irrigation at 40 and 20% of WHC, respectively.
F_0: Spraying plants with distilled water, F_1: Spraying unihumic, F_2: Spraying aminomore and F_3: Spraying unihumic + aminomore.

fractions were appeared at the well-watered plants (60% of WHC), while the lowest values were attained at the acute drought stress (20% of WHC) treatment. Total carbohydrates, total sugars, reducing sugar and non-reducing sugar were reduced by 26, 41, 35 and 48% at level of 20% WHC in the first season, respectively and by 23, 46, 34 and 58% in the second season, respectively. The moderate level of drought stress (40% of WHC) significantly reduced total carbohydrates, total sugars, reducing sugars and non-reducing sugars by 12, 16, 18 and 14% in the first season, respectively and by 11, 18, 18 and 18% in the second season, respectively.

Foliar spraying with unihumic resulted in a significant increase in carbohydrate fractions content in cowpea seeds at both studied seasons. The positive effect of humic acid on the content of carbohydrate fractions may be due to the hormonal like activity of humic acid, inhancing the absorpition of miniral nutrients due to increasing permeability, increasing number of leaves, leaf area, chlorophyll content, photosynthetic activity and consequently, the production of photosynthetic materials have increased **(Abdel-Salam, 2016)**.

Treated cowpea plant with foliar spraying of aminomore significantly increased the content of carbohydrate fractions at both seasons under normal and drought stress conditions. The positive effects of aminomore as a source of amino acids on the content of carbohydrate fractions of cowpea seeds are in good agreement with those obtained by **Sadak *et al.* (2015)** who indicated that application of amino acids as a foliar spray caused increases in the contents of total carbohydrates and polysaccharides of stressed and non-stressed bean plants.

Foliar spraying cowpea plants with a combination of unihumic and aminomore significantly increased the content of carbohydrate fractions during both seasons under normal and drought stress conditions. This treatment produced the largest value of carbohydrate fractions as compared to the other treatments. The positive effect of unihumic and aminomore on the content of carbohydrate fractions may be due to increasing plant growth processes within the leaves and increase of photosynthetic activity, which results in higher carbohydrates content in seeds **(El-Ghamry *et al.*, 2009).**

The combination between drought stress and the treatments of unihumic and aminomore on carbohydrate fractions of cowpea seeds was insignificant. The highest value of carbohydrate fractions was recorded under the well-watered plants at 60% WHC and foliar spraying with unihumic and aminomore. However, the lowest value of carbohydrate content was detected in the plants subjected to severe drought stress (20% WHC) and untreated with either unihumic or aminomore.

Protein concentration

Table 6 shows that increasing level of drought stress significantly decreased protein concentration in seeds of both seasons. The highest values was appeared at control plants (60% of WHC), while significantly reduced by 47 and 44% below the control in the first and second seasons at the severe level of drought stress (20% of WHC). The moderate level of drought stress (40% WHC) reduced the concentration of protein in cowpea seeds by 22% as compared to the well-watered plants (60% WHC) in both seasons.

A reduction in protein concentration due to drought stress might be attributed to the reduction in absorption of mineral nutrients, relative water content, changes in cell membrane penetrability and reducing in its sustainability **(Blokhina *et al.*, 2003)**.

Unihumic as a foliar spraying resulted in a significant increases in protein concentration of seeds at both growing seasons. The effect of unihumic on protein concentration of cowpea plants may be refered to the role of humic acid in increasing the availability of nutrients **(El-Shafey and Zen El-Dein, 2016)**.

Treated cowpea plant with aminomore foliar spraying was significantly increased protein concentration in cowpea seeds at both seasons under normal and drought stress conditions. Amino acids as a foliar treatment promoted the synthesis of DNA and RNA and prevented their degradation by nuclease enzymes. It was also reacting directly or indirectly with reactive oxygen species, thus contributed to maintain the integrity of cell structure such as lipids, proteins and nucleic acids from damage which was induced by stresses **(Neuberg *et al.*, 2010).**

Table 7. Effect of foliar application with unihumic and aminomore combination on anatomical features of cowpea leaf cv. Tepa during the second growing season (2016) at the age of 45 days

Characteristics	Drought stress					Foliar spraying (Unihumic and Aminomore)					
	60% of WHC (Control)	40% of WHC	± Control	20% of WHC	± Control	60% of WHC	± Control	40% of WHC	± Control	20% of WHC	± Control
Midvein thickness (µm)	1096.7	996.4	- 9.1	877.3	- 20.0	1171.9	+ 6.9	1140.5	+ 4.0	1251.4	+ 14.1
Lamina thickness (µm)	327.3	290.2	- 11.3	222.6	- 32.0	324.3	- 0.9	273.9	- 16.3	298.4	- 8.8
Palisade tissue thickness (µm)	168.3	147.3	- 12.5	86.1	- 48.8	158.4	- 5.9	134.6	- 20.0	172.2	+ 2.3
Spongy tissue thickness (µm)	108.9	102.8	- 5.6	96.0	- 11.8	118.6	+ 8.9	99.0	- 9.1	85.0	- 21.9
Midvein bundle length (µm)	720.7	658.0	- 8.7	407.3	- 43.5	927.5	+ 28.7	758.3	+ 5.2	789.7	+ 9.6
Midvein bundle width (µm)	733.2	873.4	+ 19.1	401.1	- 45.3	846.0	+ 15.4	752.0	+ 2.6	746.9	+ 1.9
Number of xylem vessel	9.0	10.0	+ 11.1	4.7	- 47.8	10.3	+ 14.4	13.1	+ 45.6	8.3	- 7.8
Average diameter of xylem vessel (µm)	47.5	44.6	- 6.1	29.7	- 37.5	49.5	+ 4.2	49.5	+ 4.2	41.6	- 12.4
Thickness of upper epidermis (µm)	29.7	28.0	- 5.7	21.5	- 27.6	29.7	0.0	21.8	- 26.6	24.8	- 16.5
Thickness of lower epidermis (µm)	19.8	14.9	- 24.7	16.8	- 15.2	14.9	- 24.7	19.8	0.0	17.6	- 11.1

Foliar spraying cowpea plants with a combination of unihumic and aminomore significantly increased protein concentration in cowpea seeds during both seasons under normal and drought stress conditions. This treatment produced the largest value of protein as compared to the other treatments. The effects of both unihumic and aminomore on protein concentration of cowpea seeds can be discussed on the basis that amino acid protect cell membranes from stress by enhancing activities of various antioxidants, plasma membrane stabilization and action as a protectant of enzymes and membranes. However, humic substances promoted growth and mineral nutrient uptake of plant due to the better-developed of root systems **(Bakry *et al.*, 2014).**

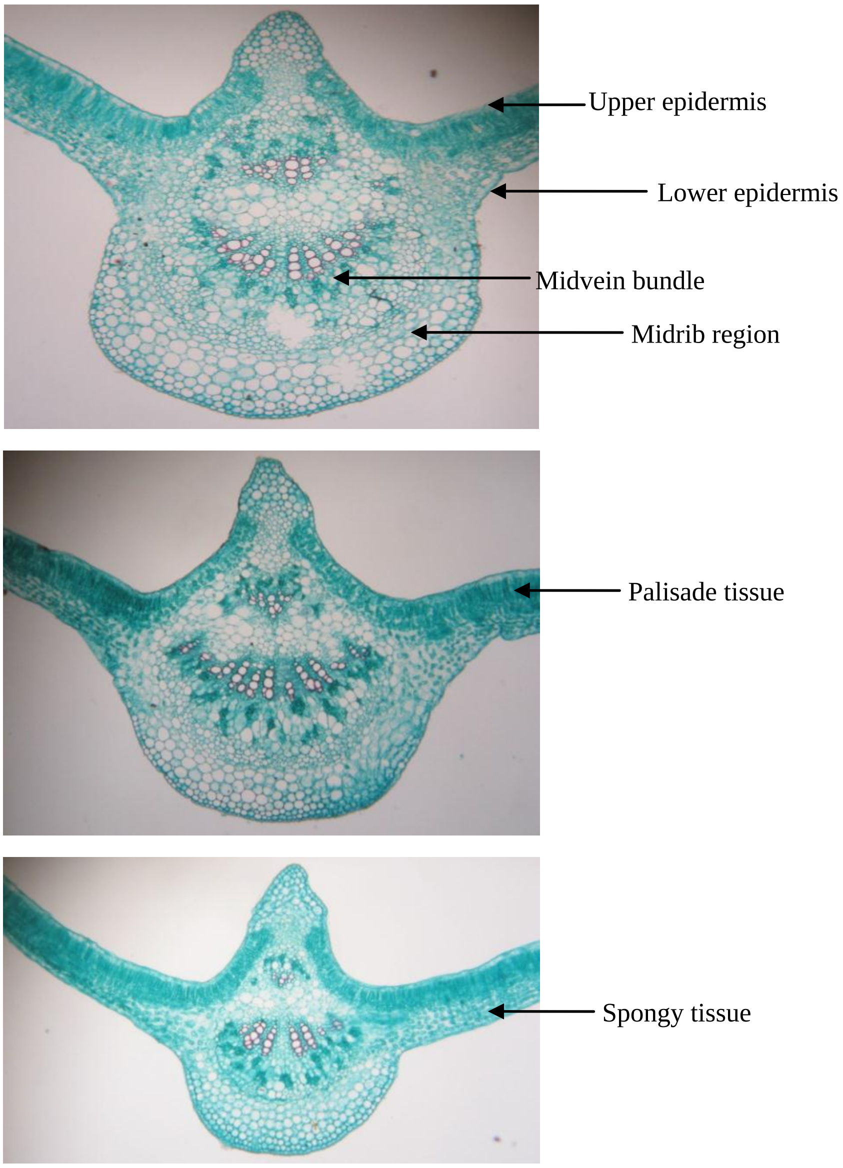
The combination between drought stress and the treatments of unihumic and aminomore was insignificant in both seasons. The lowest values was detected under acute drought stress at 20% WHC and untreated with either unihumic or aminomore. However, the highest value was recorded under the well-watered plants at 60% WHC and foliar spraying with unihumic and aminomore.

Anatomical Features

The effect of drought stress

Results in Table 7 and Fig. 1 note that cowpea plants cv. Tepa grown under drought stress at level 40% reduced the thickness of both midvein and lamina of leaflet by 9.1 and 11.3%, respectively. It was cleared that the reduction in lamina could be attributed to the decrements in thickness of palisade tissue, spongy tissue, upper and lower epidermis by 12.5, 5.6, 5.7 and 24.7%, respectively. The midvein bundle showed notable decrease in length by 8.7%, but an increase in width by 19.1% than the control. Also, number of xylem vessels/midvein bundle was increased by 11.1% more than control; however the mean diameter of vessel was decreased by 6.1% less than the control.

Likewise, it was noticed that drought stress at the level of 20 % exhibited reduction in thickness of both midvein and lamina of leaflet blade by 20 and 32% less than control, respectively. The reduced in thickness of lamina attributed to the decrease in thickness of epidermis and thickness of mesophyll tissue. The thickness of palisade tissue, spongy tissue,



(A)

(B)

(C)

Fig. 1. Effect of drought stress on anatomical features of cowpea leaf cv. Tepa through the second growing season-x100

Where**:** **A.** From plants grown at level of 60% WHC (Control)

B. From plants grown under drought stress at level of 40% WHC

C. From plants grown under drought stress at level of 20% WHC upper and lower epidermis were also decreased by 48.8, 11.8, 27.6 and 15.2% below the control, respectively. Such treatment decreased the size of midvein bundle by 43.5% in length and by 45.3% in width below the control. Moreover, the number of xylem vessels/midvein bundle and the mean diameter of vessel were decreased by 47.8 and 37.5%, respectively compared to the control. This is in agreement with **Selim *et al.* (2019),** who cleared that flag leaves of wheat plants were thinner due to reducing thickness of both midvein bundle in width and length, lamina, metaxylem vessel diameter and thickness of phloem tissue under drought stress conditions.

The effect of unihumic and aminomore combination on anatomical features of cowpea leaf

Results in Table 7 and Fig. 2 indicate that the effect of foliar spraying with unihumic at the rate of 1.5 ml/l and aminomore at the rate of 1 ml/l on cowpea plants grown under adequate water level of 60% of WHC. It is realized that application of unihumic and aminomore combination induced appropriate changes in leaflet structure by increasing in midvein thickness by 6.9% than control. Slight reduction in thickness of lamina by 0.9% below the control, which may be attributed to reduction in thickness of palisade tissues and lower epidermis by 5.9 and 24.7%, respectively.

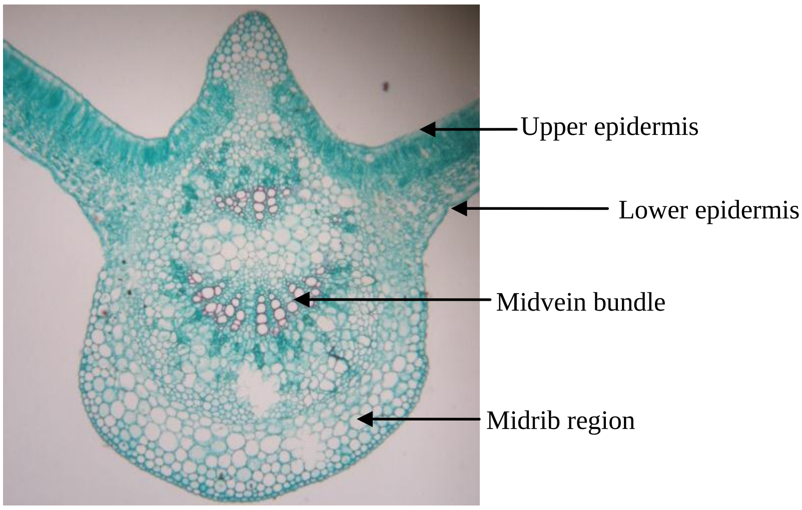
However, thickness of spongy tissue was increased by 8.9% and thickness of upper epidermis was not affected compared to the control. The increase in size and components of midvein bundle (midvein bundle length, midvein bundle width, number of xylem vessels/midvein bundle and mean diameter of vessel) were increased by 28.7, 15.4, 14.4 and 4.2% over the control, respectively.

Results also revealed that, the impact of foliar spraying with unihumic and aminomore on cowpea plants grown under drought stress at the level of 40 % of WHC showed increased in midvein thickness of leaflet blades by 4% and size of midvein bundle in length and in width by 5.2 and 2.6%, respectively over the control. It was cleared that lamina thickness was decreased by 16.3%, which due to decrease in thickness of palisade, spongy tissues and upper epidermis by 20, 9.1 and 26.6%, respectively compared with control plants. However, thickness of lower epidermis was not affected. Also, the number of xylem vessels/midvein bundle and mean diameter of vessel were increased by 45.6 and 4.2%, respectively more than the control.

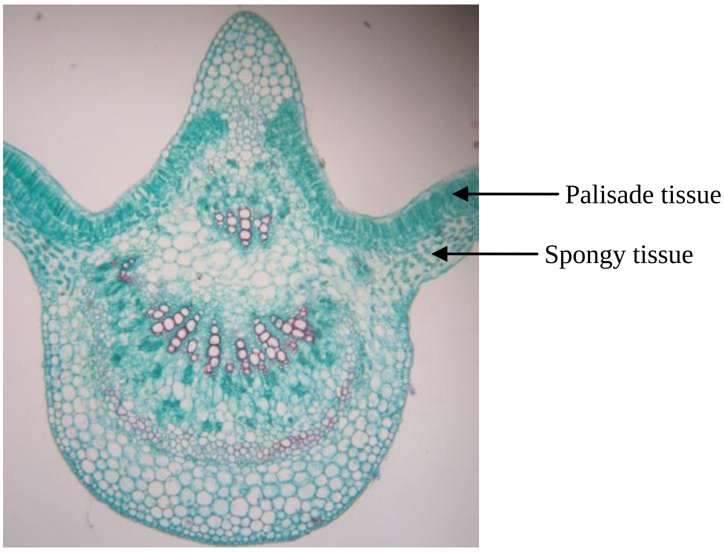
Foliar application with unihumic and aminomore on cowpea plants grown under drought stress at the level 20% of WHC induced a prominent increase in midvein thickness by 14.1% over the control, but lamina thickness of leaflet was decreased by 8.8%. The decrease in lamina thickness could be attributed to the reduction in thickness of upper and lower epidermis as well as in spongy tissue by 16.5, 11.1 and 21.9%, respectively. However palisade tissue showed slight increment by 2.3% than control plants. The main vascular bundle of the midvein was increased in size. This increase was mainly due to the increase in length by 9.6% and in width by 1.9% compared to the control. Xylem vessel number and vessel diameter were decreased by 7.8 and 12.4%, respectively compared to the control. The obtained results are in agreement with **Salama *et al*. (2018)** who found that treating plants with Potassium humate significantly increased the values of leaf anatomical characters which had the highest values of the thickness of midvein, lamina, palisade, spongy, xylem, phloem tissues and length and width of vascular bundle of midvein.

Conclusion

It could be concluded that drought stress had adverse effect on the growth, physiological and biochemical parameters, yield and anatomical features on leaf of cowpea plants. However, subjecting cowpea plants to foliar spraying with either unihumic or aminomore and their combination alleviated the adverse effect of drought stress. The best treatment was foliar spraying with the combination of unihumic and aminomore on cowpea plants grown under 60 % of WHC. The authors recommended that using foliar spraying with the combination of unihumic and aminomore under drought stress 40% of WHC enhanced cowpea growth, physiological parameters, yield and anatomical features on leaf in addition to water saving of 20% comparing with adequate level 60 % of WHC.



(A)

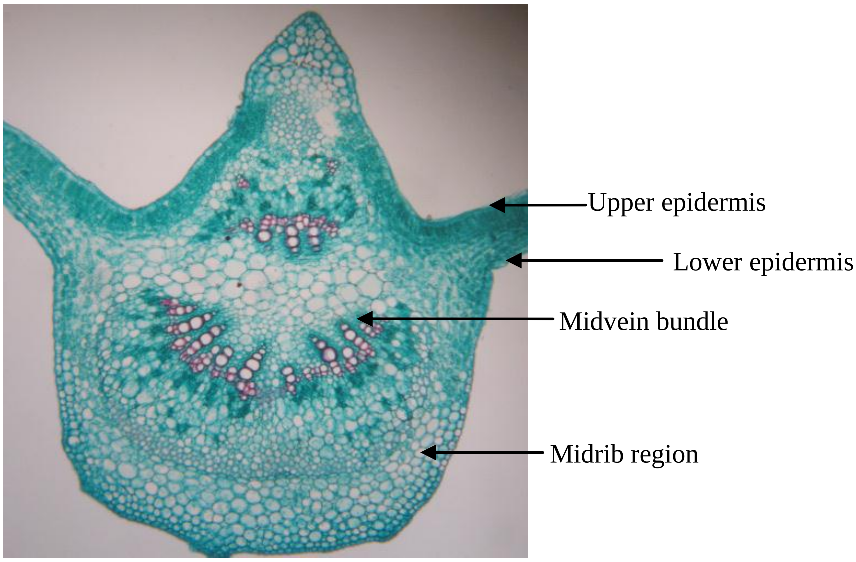


(B)

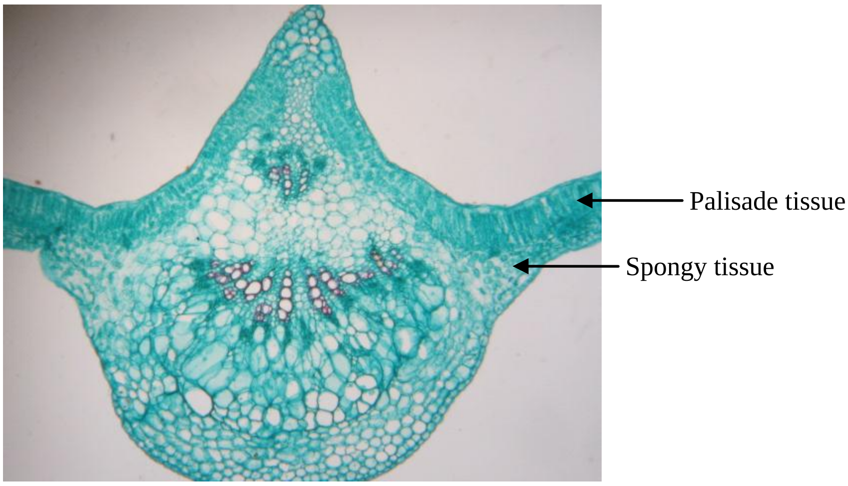
Fig. 2. Effect of foliar application with unihumic and aminomore combination on anatomical features of cowpea leaf cv. Tepa during the second growing season-x100

Where**:** **A.** From plants grown at level of 60% WHC (Control)

B. From plants grown at level of 60% WHC and sprayed with unihumic and aminomore



(C)



(D)

Cont. (Fig. 2)

Where: **C.** From plants grown under drought stress at level of 40% WHC and prayed with unihumic and aminomore

D. From plants grown under drought stress at level of 20% WHC and sprayed with unihumic and aminomore

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تأثير اليونى هيوميك والأمينومور على نباتات اللوبيا النامية تحت ظروف إجهاد الجفاف

صفاء مراد على إبراهيم أرناؤوط ـ نادية حسين كامل ـ حسن محمد حسن المسلمى ـ محمد سليم بغدادى

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أجريت تجربتى أصص خلال موسمى ٢٠١٥ و ٢٠١٦ بالصوبة السلكية بكلية الزراعة، جامعة الزقازيق، محافظة الشرقية، مصر وذلك لدراسة تأثير الرش الورقي باستخدام اليونى هيوميك والأمينومور ومزيجهما على النمو، الصفات الفسيولوجية، إنتاجية المحصول بالإضافة إلى الصفات التشريحية لأوراق نباتات اللوبيا صنف طيبة المزروعة تحت مستويات الجفاف المختلفة (٢٠ و٤٠% من السعة التشبعية للتربة) مقارنة بالمستوى الملائم ٦٠% من السعة التشبعية للتربة، أظهرت النتائج أن إجهاد الجفاف عند نسبة ٤٠% أو ٢٠% من السعة التشبعية للتربة قد قلل بشكل كبير من جميع خصائص النمو (أطوال النباتات، مساحة أوراق النبات، عدد الفروع/النبات والوزن الجاف للنباتات)، الصفات الفسيولوجية (صبغات التمثيل الضوئي و الكربوهيدرات في الأوراق)، مكونات المحصول (عدد القرون/نبات، عدد البذور/قرن، وزن البذور/نبات، وزن ١٠٠ بذرة) والتحليلات الكيماوية للبذرة (محتوى الكربوهيدرات والبروتين) مقارنة بمستوى ٦٠% سعة تشبعية، الرش باستخدام اليوني هيوميك أو الأمينومور أو الخليط بينهما أدى إلى زيادة معدلات النمو والصفات الفسيولوجية وكذلك مكونات المحصول لنباتات اللوبيا تحت مستويات الجفاف المختلفة، فيما يتعلق بالصفات التشريحية للورقة أشارت النتائج إلى أن إجهاد الجفاف بنسبة ٢٠% أو ٤٠% من السعة التشبعية للتربة قلل كلا من سمك النصل، سمك النسيج العمادي والأسفنجي، سمك البشرة العليا والسفلى، أبعاد الحزمة الوعائية، كذلك متوسط قطر وعاء الخشب وجد انه يقل بزيادة مستويات الجفاف، بينما باستخدام خليط من اليوني هيوميك والأمينومور رشاً على النباتات أدى إلى زيادة وتحسين الصفات التشريحية للورقة فيما عدا نقص طفيف فى سمك النصل، سمك النسيج العمادى و سمك البشرة السفلى.

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