Effect of Cultivars, Foliar Application of Ascorbic Acid and Amino Acids on some Physiological Parameters of Okra Plant.

Khalid A. A. Hashim and Fouad A. Salman

Faculty of Agriculture,University of Kufa , Iraq

E-mail: fouad.alibraheemi@uokufa.edu.iq

Abstract

This study was conducted in the Orchards Development Project, Medicinal and Aromatic Plants, which belongs to the Holy Karbala Agriculture Directorate during the summer agricultural season 2020.To study the response of three okra cultivars (Lahaloba, Batira and Hasinawi) to foliar treatment with ascorbic acid at a concentration of 100 mg. L^{-1} with total amino acids at a concentration of 4 g. L^{-1} The interaction of 100 mg.L^{-1} ascorbic acid was studied. and amino acids by 4 g. L^{-1} In addition to the control treatment of and interaction between them in some indicators of growth and productivity of okra, the experiment was conducted as a factorial experiment according to the Randomized Complete Block Design (RCBD) and with a split plot system and with three replications. The averages were compared according to the least significant difference test (L.S.D.). at the 0.05 probability level. The results showed the Hasinawi cultivar excelled in increasing the plant height to 192.62 cm and the number of leaves to 162.58 leaves. $Plant^{-1}$ and the average dry weight of the shoot total to 13.67 g. $Plant^{-1}$, while the cultivar Batira was exceled in increasing the leaves content of total chlorophyll to 81.41 mg. 100 gm^{-1} fresh weight. Spraying with ascorbic acid and total amino acids had a significant effect on vegetative growth indicators and gave the interaction between 100 mg.L^{-1} and 4 g. L^{-1} has the highest averages in these indicators compared to the control plants.

Introduction

Okra plant. *Abelmoschus esculentus* L is one of the vegetable crops belonging to the Malvaceae family, and the regions of Ethiopia, Eritrea, Sudan, and Egypt are its original country . It is also cultivated in most of the tropical regions of the world (21).The total cultivated areas in the world amounted to more than 20 million hectares, with a productivity of 9,872,826 tons, while the total cultivated area in Iraq was 12.128 hectares, with a productivity of 68,451 tons (10).Okra is grown in order to obtain its green pods, which are rich in nutrients such as phosphorous, calcium and magnesium. It also contains some vitamins such as riboflavin and thiamine, as well as vitamin A and vitamin C (5).The fruits of this plant or some of its vegetative parts are also included in some industries as raw materials. The gelatinous substance that is extracted from the pods, stems, and roots is used to filter sugar cane juice or as an adhesive to the leaves. Fiber is also used in paper industries (9)Also, its seeds are no less important than the fruits. They may be roasted to mix with coffee seeds or used as a substitute for it. Also, its mature seeds have a high oil content of about 20%, so they are used in edible oil (1).cultivars are one of the most important factors that determine the success of plant cultivation in a particular area, by interfering with the environmental conditions prevailing in that region. It was explained (6 and 15) that the environment and the genetic factor of the cultivated okra variety greatly affect the quantity and quality of the yield.cultivars are selected for cultivation in a specific area on the basis of their distinction in a number of qualities that enable them to give an appropriate quantitative yield and an appropriate qualitative

 ISSN 2072-3875

yield through the quality of the pods represented in their shape, size, color and taste, which make them desirable to the consumer, as well as their tolerance to varying environmental conditions and the extent of their resistance to types of pests. prevalent (8).Ascorbic acid with the chemical formula (C6 H8 O6), and it is one of the basic components necessary in high-end plants that need it in small quantities to maintain their normal growth, as it performs several functions within the plant tissues, including reducing the effect of stress caused by temperature and toxins and stimulating Respiration processes, cell division, and increasing the effectiveness of a number of enzymes, as well as entering the electron transport system, also keeps chloroplast from oxidation as it is one of the counter factors (14 and 17).Amino acids are one of the basic and important components in the process of manufacturing protein and nucleic acids, where they enter into the formation of plant tissues and chlorophyll, as well as in the chelation of nutrients in the soil and increase their availability and absorption by the plant and their transfer as well as activate and enter into the bio-building of some plant hormones ,They are carboxylic acids that contain one or more amino groups. The basic structural unit in proteins is alpha-amino acids, in which the amino group is attached to the alpha carbon atom, which is the atom next to the carboxylic group, and it has an important role in the metabolism process. and physiological processes (11 and 16).(19) described that the absorbed amino acids are only vital stimulants and have positive effects in increasing the average of plant growth and activating its vital interactions, while (4) indicated an increase in vegetative growth and improvement of the qualitative traits of Eruca sativa Mill. when foliar treatment with amino acid Tyrosine. Based on the foregoing, this research aims to study the response of some local okra cultivars grown in Iraq to spraying with ascorbic acid and total amino acids and the interaction between them in some indicators of vegetative growth and its reflection on the fruit yield.

Materials and Methods

The experiment was conducted in a project to develop orchards and medicinal and aromatic plants, which is one of the projects of the Plant Production Department , Karbala Agriculture Directorate, Ministry of Agriculture in the Umm Gharagir area, north of the Holy Karbala province, during the spring season 2020.The field was prepared with a tillage procedure with a depth of 30-40 cm, then smoothed and decomposed organic fertilizer was added at an amount of 40 m3. ha^{-1}, and the soil was sterilized using the biocidal Tricozole against Nematode and fungal diseases.The okra seeds and for the three studied cultivars were soaked with water for 24 hours, and on the next day they were planted in the Al-Furrow system on March 15, 2020. And the last 50 cm, and between one line and another 75 cm, and the width of one Furrow is 75 cm. Thus, the area of the experimental unit is 7.50 m 2 (10 m Furrow length x 0.75 m of Furrow width), so the number of plants in one experimental unit is 20 plants and the irrigation system used was drip irrigation. The experiment included two factors, the first factor. Three locally grown okra cultivars (Lahaloba, Batira and Hasinawi) were studied.As for the second factor, it included four levels of spraying, which is ascorbic acid spray at a level of 100 mg. L^{-1} and spray total amino acids at a level of 4 g. L^{-1} and the mixture consisting of spraying ascorbic acid at a level of 100 mg. L^{-1} and total amino acids at a level of 4 g. L^{-1} while It sprayed the control treatment with water only, Plants were sprayed in the early morning until completely wetness using a 6-liter hand-held sprayer. A 0.1% diffuser was added to break the healthy tension of the solution. The experiment was conducted using a completely randomized complete block design and a split plot design, where the items were distributed within the main-plots, with three replicates, and each replicate had twelve experimental units,

 ISSN 2072-3875

thus the number of experimental units was 36 experimental units. Then ANOVA was conducted according to the Least Significant (L.S.D.) test at the 0.05 probability level, then the experimental data were analyzed using the Genstat Release 12 program.

Studied traits:

1- plant height (cm)

2- Number of leaves (leaf. plant^{-1}):

3- Total leaf area (dm^2. Plant^{-1})

4- Dry weight of the vegetative system (g. plant^{-1}):

5- Total chlorophyll content of leaves (mg.100g^{-1} fresh weight):

6- The plant yield (kg. plant^{-1})

7- The total yield of pods (ton. ha^{-1})

Results and Discussion

1 - plant height (cm)

Table (1) showed that the Hasinawi cultivar significantly excelled in increasing the plant height, which reached 192.62 cm, compared with the study cultivars, and the lowest average was in Lahaloba cultivar, which was 170.92 cm. The combination of ascorbic acid and total amino acids was significantly excelled in increasing plant height 186.12 cm, Compared to the control treatment, which recorded 173.61 cm. The interaction between the cultivars and the spraying treatments had a significantly effect on the studied trait, where the Hasinawi cultivar treatment with the combination of spraying with ascorbic acid and total amino acids significantly increased the height to 204.86 cm.

Table (1): Effect of cultivars and spraying with ascorbic acid and total amino acids on plant height (cm)

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	168.86	169.21	166.49	179.12	170.92
Batira	172.72	171.49	172.76	174.37	172.84
Hasinawi	179.25	191.61	194.77	204.87	192.62
Treatments effect	173.61	177.44	178.00	186.12	
L.S.D 0.05	Cultivars		Treatments		Interaction
	4.229		4.884		8.459

2- Number of leaves (leaf. plant $^{-1}$)

Table (3) showed that the Hasinawi cultivar significantly excelled in increasing the number of leaves to 162.58 leaves. Plant^{-1} compared to Lahaloba cultivar decreased to 81.74 leaves. Plant^{-1}, the combination of ascorbic acid and total amino acids significantly increased the number of leaves to 150.81 leaves. Plant^{-1},Compared with the control treatment, which recorded 111.76 leaves. Plant-1. As for the effect of the interaction between cultivars and spraying treatments, Hasinawi cultivar treatment with the combination of spraying with ascorbic

ISSN 2072-3875

acid and total amino acids significantly increased the number of leaves to 188.36 leaves. plant^{-1}.

Table (2): Effect of cultivar and spraying with ascorbic acid and total amino acids on number of leaves (leaf. plant^{-1})

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	64.92	74.18	84.86	102.99	**81.74**
Batira	141.45	148.99	142.37	161.08	**148.47**
Hasinawi	128.91	151.02	182.01	188.36	**162.58**
Treatments effect	**111.76**	**124.73**	**136.41**	**150.81**	
L.S.D 0.05	Cultivars		Treatments		Interaction
	2.490		**2.876**		**4.981**

Total leaf area (dm^2.plant^{-1})

The results in Table (3) showed that the Hasinawi cultivar was significantly excelled in increasing the leaf area to 221.86 dm^2.plant^{-1}, and the lowest average was in the Lahaloba cultivar 90.49 dm^2.plant^{-1}. As for the effect of spraying treatments, the combination of ascorbic acid with total amino acids significantly increased the leaf area, which amounted to 190.18 dm^2.plant^{-1},Compared with the control treatment, in which the leaf area decreased to 119.62 dm2. Plant -1, and the interaction between cultivars and spraying treatments had a significant effect on this trait, where Hasinawi cultivar excelled with the combination of spraying with ascorbic acid and total amino acids in increasing the leaf area to 273.54 dm^2.plant^{-1}, compared to the interaction between the cultivar Lahaloba with the control treatment, which gave the least leaf area of 65.44 dm^2.plant^{-1}.

Table (3): Effect of cultivar and spraying with ascorbic acid and total amino acids on total leaf area (dm^2. Plant^{-1})

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	65.44	81.39	96.30	118.83	**90.49**
Batira	131.28	151.84	151.77	178.17	**153.27**
Hasinawi	162.15	197.84	253.93	273.54	**221.86**
Treatments effect	**119.62**	**143.69**	**167.33**	**190.18**	
L.S.D 0.05	Cultivars		Treatments		Interaction
	4.226		**4.915**		**8.513**

ISSN 2072-3875

Dry weight of vegetative growth (g.plant^{-1})

The results in Table (4) showed the Hasinawi cultivar excelled in increasing the dry weight of the vegetative growth to 13.67 g.plant^{-1}, while the lowest average dry weight of vegetative growth at Lahaloba cultivar was 11.88 g.plant^{-1}. The combination of ascorbic acid and total amino acids significantly increased the dry weight of vegetative growth to 13.48 g.plant^{-1}, compared to the control treatment, in which the dry weight was reduced to 11.35 g.plant^{-1}.The interaction between the cultivars and the spraying treatments was excelled on the treatment of the Hasinawi cultivar with the combination of spraying with ascorbic acid and total amino acids to 14.49 g.plant^{-1}.

Table (4): Effect of cultivar and spraying with ascorbic acid and total amino acids on the average dry weight of the shoot (g. plant^{-1})

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	11.00	11.61	12.06	12.86	**11.88**
Batira	10.69	12.97	12.66	13.09	**12.35**
Hasinawi	12.38	14.04	13.75	14.49	**13.67**
Treatments effect	**11.35**	**12.87**	**12.82**	**13.48**	
L.S.D 0.05	Cultivars		Treatments		Interaction
	0.434		**0.501**		**0.868**

Total chlorophyll content of leaves (mg.100g^{-1} fresh weight)

The results in Table (5) showed that the cultivars had no significant effect on the total chlorophyll content of leaves. While the combination of ascorbic acid and total amino acids was significantly superior in increasing the total chlorophyll average to 83.43 mg.100g^{-1} fresh weight. Compared with the control treatment, which recorded 78.37 mg.100g^{-1} fresh weight. The interaction between the cultivars and the spraying treatments had a significant effect on the aforementioned trait, where the Hasinawi cultivar was excelled on the combination of spraying with ascorbic acid and total amino acids in increasing the content to 84.22 mg.100g^{-1} fresh weight.

Table (5): Effect of cultivar and spraying with ascorbic acid and total amino acids and the interaction between them on the total chlorophyll content of leaves (mg. 100 gm-1 fresh weight)

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	76.70	78.66	81.17	82.42	**79.73**
Batira	79.33	80.43	82.30	83.67	**81.43**
Hasinawi	79.08	80.00	82.65	84.22	**81.48**
Treatments effect	**78.37**	**79.69**	**82.04**	**83.43**	
L.S.D 0.05	Cultivars		Treatments		Interaction

ISSN 2072-3875

Yield per plant (kg. plant^{-1})

Through the results in Table (6), showed that the cultivar Lahaloba was excelled in increasing the plant yield to 1.43 kg. plant^{-1} compared to the rest of the cultivars, and the lowest average was in the cultivar Batira, which recorded 1.26 kg. plant^{-1}. The combination of ascorbic acid and total amino acids was significantly excelled in increasing the plant yield , as it reached 1.50 kg. plant^{-1}.Compared with the control treatment, which recorded 1.16 kg. plant^{-1}. The interaction between the cultivars and the spraying treatments showed a significant effect, where the treatment of Lahaloba cultivars with the combination of spraying with ascorbic acid and total amino acids significantly increased the plant yield , amounting to 1.70 kg. plant^{-1}, while the cultivar Batira with the control treatment showed a decrease in yield amounting to 1.09 kg. plant^{-1}.

Table (6): Effect of cultivar and spraying with ascorbic acid and total amino acids on the yield of one plant (kg.plant^{-1})

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	1.39	1.45	1.39	1.70	**1.43**
Batira	1.09	1.25	1.31	1.40	**1.26**
Hasinawi	1.20	1.31	1.36	140	**1.32**
Treatments effect	**1.16**	**1.34**	**1.35**	**1.50**	
L.S.D 0.05	Cultivars		Treatments		Interaction
	0.034		**0.039**		**0.068**

Total yield (ton. ha^{-1})

The results in Table (7) indicated that the Lahaloba cultivar was excelled in increasing the total yield to 1.97 ton. ha^{-1}, compared to the Batira cultivar , which recorded 1.64 ton. ha^{-1}. The combination of ascorbic acid and total amino acids was significantly excelled in increasing the total yield to 1.99 ton. ha^{-1}, compared with the control treatment, which decreased to 1.63 ton. ha^{-1}, and the interaction between cultivars and spraying treatments was excelled on Lahaloba cultivar treatment with the combination of ascorbic acid and total amino acids in increasing the total yield to 2.26 ton. ha^{-1}.The Hasinawi cultivar excelled in most indicators of vegetative growth. This may be due to a role in the genetic differences caused between the studied cultivars due to the differences between the genes and the genetic nature of these cultivars , which resulted in these differences in the rate of vegetative growth (7 and 15). On the other hand, it is noted Lahaloba cultivar. It has achieved a significant increase in the average of yield, despite the Hasinawi cultivar excelled in the average of vegetative growth, but it has no economic value compared to the yield. The Lahaloba cultivar is considered to be of economic value and suitable for cultivation under the conditions of Karbala province

ISSN 2072-3875

Table (7): Effect of cultivar and spraying with ascorbic acid and total amino acids on the total yield (ton.ha^{-1})

Cultivars	Treatments				Cultivar effect
	Control	Ascorbic acid 100mg.L^{-1}	Total amino acids 4g.L^{-1}	Ascorbic acid + total amino acids	
Lahaloba	1.85	1.93	1.85	2.26	**1.97**
Batira	1.45	1.66	1.74	1.86	**1.67**
Hasinawi	1.60	1.74	1.36	1.86	**1.64**
Treatments effect	**1.63**	**1.77**	**1.65**	**1.99**	
L.S.D 0.05	Cultivars		Treatments		Interaction
	0.3767		**0.4349**		**0.7533**

The reason may be due to the fact that the prevailing temperatures did not affect the vitality of pollen grains or the ability of flowering stigmas to receive those grains, which resulted in an increase in the rate of set, and that this increase was positively reflected in the increase in the yield of one plant and then on the average of the total yield . Through the previous tables, it is noted that there are significant differences in all characteristics of vegetative growth, namely plant height, leaf area and number of leaves as a result of spraying ascorbic acid, and this is due to the role of this acid in preserving and protecting living cells from oxidation processes (3) On the other hand, the external addition of ascorbic acid to plants leads to stimulating growth through its activation of some enzymes of vital reactions, as well as stimulating the division and expansion of cells, as well as because of its key role in the process of biological construction of many plant hormones (20) This is reflected positively in the increase in cell division and differentiation and increase in their number, thus improving the traits of vegetative growth, including the increase in the number of leaves and leaf area, and this is consistent with what was found (2) who noted that there was an improvement in the growth average of okra plant when treated with ascorbic acid. The amino acids had a significant effect in improving the vegetative growth traits .Through its role in building the enzyme systems and the bases of the various pyrimidine and purine and increasing the formation of nucleic acids DNA and RNA (23) On the other hand, the foliar feeding with amino acids and their absorption directly by the leaf cells has caused an increase in the nutritional content of the plant by increasing the efficiency of the photosynthesis processes and carbon metabolism, and thus had a positive effect in increasing the accumulation of nutrients manufactured by the plant, such as carbohydrates (12 and 18),or the role of these acids in increasing the protein content of plant tissues through the merging of these amino acids with each other and forming proteins (24). This was generally reflected in the increase in dry weight.

Conclusions

1- The cultivar Lahaloba achieved a significantly excelled on the cultivar Hasinawi and Batira in increasing the yield indicators.

2- It was spraying the mixture of ascorbic acid at a concentration of 100 mg. L^{-1} and total amino acids at a concentration of 4 g. L^{-1} had a significant effect in improving all indicators of vegetative growth, and then this was reflected positively in increasing the yield of pods.

ISSN 2072-3875

References

1- Abdul Rahman , F. A. and H. A. Nadir .2018. Effect of water stress on okra (*Abelmoschus esculentus* L.) yield at vegetative stage. AGRIC Vol . 30(2): 111-116.

2- Aboohanah , Manssoor Abed .2016.The Effect of Spraying Ascorbic and Humic acid on Growth Parameters and Yield of Okra Plant (*Abelmoschus esculentus* L . Moench.) . Al-Kufa University Journal for Biology,8(3):54-65.

3- Afzal, I.; S. M. A. Basra ; M. Farooq and A. Nawaz . 2006. Alleviation of salinity stress in spring wheat by hormonal priming with ABA, salicylic acid and ascorbic acid . International J. Agric. and Bio., 8 (1) : 23-28 .

4- AL-Mohammad M.H. and K.A. AL-Taey. 2019. Effect of tyrosine and sulfur on growth, yield and antioxidant compounds in arugula leaves and seeds. Res. on Crops 20 (1) : 116-120 10.31830/2348-7542.2019.016. DOI : 10.31830/2348-7542.2019.016

5- Amin, B., G. Mahleghah, H.M.R. Mahmood, and M. Hossein .2009. Evaluation of interaction effect of drought stress with ascorbate and salicylic acid on some of physiological and biochemical parameters in okra (*Hibiscus esculentus* L.).*Res. J. Biol. Sci*., 4: 380-387.

6- Amiteye ,Samuel, Theophilus Amitaaba and Harry M. Amoatey. 2019.Morphological Characterization of Accessions of Okra (*Abelmoschus Spp.* L.).Int.pure App.Biosci., 7(1): 1-13

7- Amoatey, H. M., Klu, G. Y. P., Quartey, E. K., Doku, H. A., Sossah, F. L., Segbefia, M. M., Ahiakpa, J. K.2015. Genetic Diversity Studies in 29 Accessions of Okra (*Abelmoschus spp* L.) Using 13 Quantitative Traits. American J of Experimental Agriculture 5(3): 217-225.

8- Bisht, I. S. and K. V. Bhat. 2006. Genetic Resources, Chromosome Engineering and Crop Improvement okra (*Abelmoschus* spp.). Chapter 5. PP: 149–185.

9- Deeplata , S. and Rao, D.V. 2013. Study of metabolites of okra (*Ablemoschus esculentus* L.) after infection of pest. Int. J. Pharm. Sci. Rev. Res. 21(2):347-350.

10- F.A.O.2020. FAOSTAT Agriculture Data. Agriculture Production Crop. Available from. http://www.fao.org/faostat/ar/#data.

11- Faten S. A.; A.M. Shaheen,; A. A. Ahmed andAsmaa, R. M.2010.Effect of foliar application of urea and amino acids mixtures as antioxidants on growth, yield and characteristics of squash. Research Journal of Agricutural and Biological Science, 6(5):583-588

12- Frederick, K. K; M. S Marlow; K. G. Valentine and Wand, A. J. 2007. Conformational entropy in molecular recognition by proteins. Nature , 448 (7151) : 325-329.

13- Goodwin , T. W. 1976 .Chemistry and Biochemistry of Plant Pigment. 2 nd Ed. Academic Press, Sanfrancisco, USA .pp. 373 .

14- Hasan, A.M., T.J.Mohamed Ali .,D.K.A.Al-Taey .2019. Effects of Winter Foliar Fertilizing and Plant Growth Promoters on Element and Carbohydrate Contents on the Shoot of Navel Orange Sapling. *International Journal of Fruit Science*.,19(1)1-10. https://doi.org/10.1080/15538362.2019.1668331

15- Hussain, A.J. and AL-Taey, D.K.A.2020. Study the Effect of Selenium and SiO_2 Addition on Some Growth Parameters of Rocket under Water Stress. *Plant archive* . Vol. 20, Supplement 1, 2020 : 3594-3598.

16- Jaafer, H. S. 2018. Effect of the spray amino acids and drip irrigation depth on growth and yield of egg plant (*Solanum melongena* L.). Journal of Kerbala for Agricultural Sciences, 5(3): 106-115.

17- Jan , Samin Jan, Muhammad Hamayun, Sher Wali, Asmat Bibi, Humaira Guland and

Fazli Rahim. 2016. foliar application of ascorbic acid mitigates sodium chloride induced stress in eggplant (*Solanum melongena* L.). 4 (3): 318-328.

18- Khalil, A.A; E.A.M., Osman and F.A.F. Zahran .2008.Effect of amino acids and micronutrients foliar application on growth ,yield and its components and chemical characteristics .J. Agric. Sci. Mansoura Univ., 33(4):3143-3150.

19- Kowalczyk ,K.and T.Zielony . 2018 . Effect of amino acid and asahi on yield and quality of lettuce grown on rock wool .Conf.of biostimulators in modern Agriculturalulture,Warsaw,Poland.

20- Naz , Hira, Nudrat Aisha Akram and Muhamad Ashraf .2016. Impact of ascorbic acid on growth and some physiological attributes of cucumber (*Cucumis sativus*) plants under water-deficit conditions. Pak. J. Bot., 48(3): 877-883.

21- Oppong-Sekyere, D., Akromah, R., Nyamah, E. Y., Brenya, E., Yeboah, S .2012. Evaluation of some okra (*Abelmoschus spp.* L.) germplasm in Ghana. African Journal of Plant Science, 6(5): 166-178 .

22- Sadik, S .K; A. A. Al-Taweel; N. S. Dhyeab and Khalaf, M. Z. 2011. New computer program for estimating leaf area for several vegetable crops. American- Journal of Sustainable Agriculture. USA,5(2):304-309.

23- Taiz , L. and E. Zeiger . 2006. Plant physiology . 4th ed. Sinauer Associates. Inc. Publisher Sunderland , Massachus – AHS. U.S.A.

24- Tuman, Batool Mohammed and Fouad Abbass Salman.2020. Effects of plant variety and fertilization type on vegetative growth and nutritional contents in cowpea *Vigna unguiculata* L. Plant Archives , 20 (1): 1119-1123.

ISSN 2072-3875