Plant Archives Vol. 19, Supplement 2, 2019 pp. 1402-1410 e-ISSN:2581-6063 (online), ISSN:0972-5210

THE ROLE AND IMPORTANCE OF AMINO ACIDS WITHIN PLANTS : A REVIEW

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Abstract

Agronomy is one of the sensitive aspects associated with product goodness and quality. According to the rapid development of the population density and the necessity for healthy food to meet this increment in population either by the traditional agricultural methods or using modern technology, it is necessary to adopt the characteristics the biological and biochemical energies to achieve that goal. Many studies proved that amino acids play a positive role in enhancing the plant yield and quality when they are sprayed at different growth stages especially the critical ones such as the tillering and flowering stages or under stress conditions (such as drought, high temperature, frost, salinity, or pathogens), thus they contribute to reducing the stress effect of drought and salinity through the different physiological activities by changing the osmotic potential of plant tissue as well as they greatly reduce injuries caused by bio stresses. They stimulate physiological and biochemical processes and participate in protein and carbohydrate synthesis. It also believed that amino acids are accountable for cell division and producing some natural growth hormones such as IAA and GA3 and consequently increasing the yield and improving the quality.

***Keywords* :** Amino acids, biochemical process, temperature, growth hormones.

Introduction

Amino acids can be defined as the essential unit responsible for protein molecule formation. They are organic carbon acids made up of the amine (NH_2) and carboxyl (COOH) groups in addition to the alkyl (R) group which is specific to each amino acid and known as a side chain. It binds at the carbon atom (α). There are 21 amino acids type α found within proteins divided into two divisions: peptide and protein (AL-Modhafer, 2009).

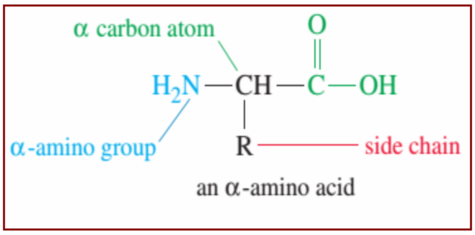


Fig. 1 : The general chemical formula of amino acids (AL-Modhafer, 2009)

Amino acids are bio activators providing a plant with energy to compensate for the losses caused by the respiration and decomposition processes. They are characterized as colorless ionic compounds soluble in cold water, hot water and alcohol to varying degrees and have a high melting point that is because they are hybrid ions. Amino acids are found in plants either freely or in combination with each other to form proteins and peptide compounds, however, the free form is the common, as the free form decomposes the petite bonds and makes the amino acids free, single, and easy to penetrate (Abd EL hafez, 2011). Amino acids are also largely found in mitochondria and chloroplast of organisms as a result of the availability of ketonic acids resulted from the assimilation of carbohydrate formed by carbon assimilation during the Kreb cycle (Beavers, 1991). The amount of amino acids varies from one plant to another depending on the metabolic processes (Abed, 2007) which can easily transmit through root hairs and pass through vessels of plants. Amino acids play an important role in many biotic processes whether they are free or as a component of proteins; therefore, their importance and effectiveness lie in the stages of plant growth. They contribute to increasing the cell ability to uptake water and solvent nutrients from growth media and then increasing the vegetative growth; moreover, they increase synthesizing proteins participating to the multiple functions of plant metabolism and enhance the carbon assimilation rate leading to increasing the total dry matter reflecting on the sink and the yield (Abu-Dahi and Al-Younis, 1988; Dreccer *et al.*, 2000; Sharma-Natu and Ghildiyal, 2005). Amino acids form a substance for synthesizing other materials such as vitamins, nucleotides, and plant growth regulators thus they are essential components of the living matter and protoplasm; furthermore, they contribute to the synthesizing enzymes as well as to the enzymatic reactions inside the cells (Kamar and Omar, 1987). Amino acids are believed to be responsible for enhancing protein contents, cell division, plant pigments, and natural hormones such as IAA, GA3, and ethylene (Ahmed and Abd El-Hameed, 2003; Ahmed *et al.*, 2007 and 2014; Madian and Refaai, 2011). Amino acids as bio inducers can also enhance the grain quality of some crops since they increase minerals absorption and enhance the use efficiency nutrient elements, where amino acids play an important role as a chelate material for each of iron, zinc, copper, magnesium, and calcium as these elements can be absorbed and passed through plant easily with helped by amino acids (Vernieri *et al.*, 2005). In addition, they balance the soil microorganisms which improve the mineralization of the organic matter resulting in fertilized well-structured soil surrounding the plant roots (Ashmead, 1986). Amino acid represents an important source for nitrogen, thus they greatly affecting the crop growth (Näsholm *et al.*, 2000; Persson and Näsholm, 2002). Some studies reported that proline accumulation is a mean used for gathering nitrogen from the compounds resulted from protein analysis (Edrees, 2009). Protein breaking down or inhibiting protein synthesis during plant subjecting to water stress conditions contributes to nitrogen aggregation that leads to formation poisonous compounds causing damage for the plant, therefore, plants have a special mechanism converting these compound into soluble nitrogenous compounds such as amino acids, the most important of which is proline. Studies proved that amino acids can affect directly or indirectly the physiological activities where they participate to protein synthesis and carbohydrate construction by constructing chlorophyll and enhancing photosynthesis as well as they contribute to stimulating the activity of many enzymes and coenzymes (El-Shabasi *et al.*, 2005; Mohamed, 2006; Al-Said and Kamal, 2008; Kowalczyk and Zielony, 2008; El-Ghamry *et al.*, 2009; Shafeek *et al.*, 2012). These results were confirmed by Kandi *et al.* (2016) who reported that spraying wheat plants by amino acids limited the rapidity of the nutrient deficiency as they are absorbed easily and used directly for protein synthesis, where Glycine is a major component of building chlorophyll within plant as it helps to increase chlorophyll concentration leading to the highest degree of photosynthesis. Some amino acids are characterized by containing sulfur as a major element participating in many plant proteins and keeping the stereoscopic structure or forming the active sites of enzymes. Among sulfuric amino acids containing Sulphur are Cysteine, Cysteine, and Methionine which are similar in containing sulfur in the side chain of their structure (Coccoti, 1996; Yassen, 2001). Sulfur function in proteins is forming the disulfide bonds (-S-S-) (sulfuric bonds) between polypeptide chains and within them causing the protein to be folded or wrapped. These bonds are important in determining the shape and structure of the protein, and they are also involved in the formation of protein enzymes (Mengel and Kerby, 1984; Havlin *et al.*, 2005). Some amino acids, including proline and arginine, also play an important role in resisting adverse conditions such as salinity, drought, and high or low temperature, where proline is one of the amino acids participating in protein synthesis. It is also observed that proline amount within a plant is proportional to the stress size, either biotic or non-biotic, that the plant subjected to, as proline accumulates in the plant parts subjected to the stress. Figure 2 illustrates briefly the role of amino acids in plant.

Points have to be considered during spraying amino acids on plant

- Spraying the amino acids during the early morning.
- Avoid mixing compounds containing calcium and sulfur with mineral oils.
- Spraying amino acids at the beginning of the critical growth stages in order to enhance the root and shoot growth.
- Sprayed plants should not be subjected to lack of phosphorus.
- In the case of use of individual amino acids, it is preferable to treat the lack of elements before spraying.

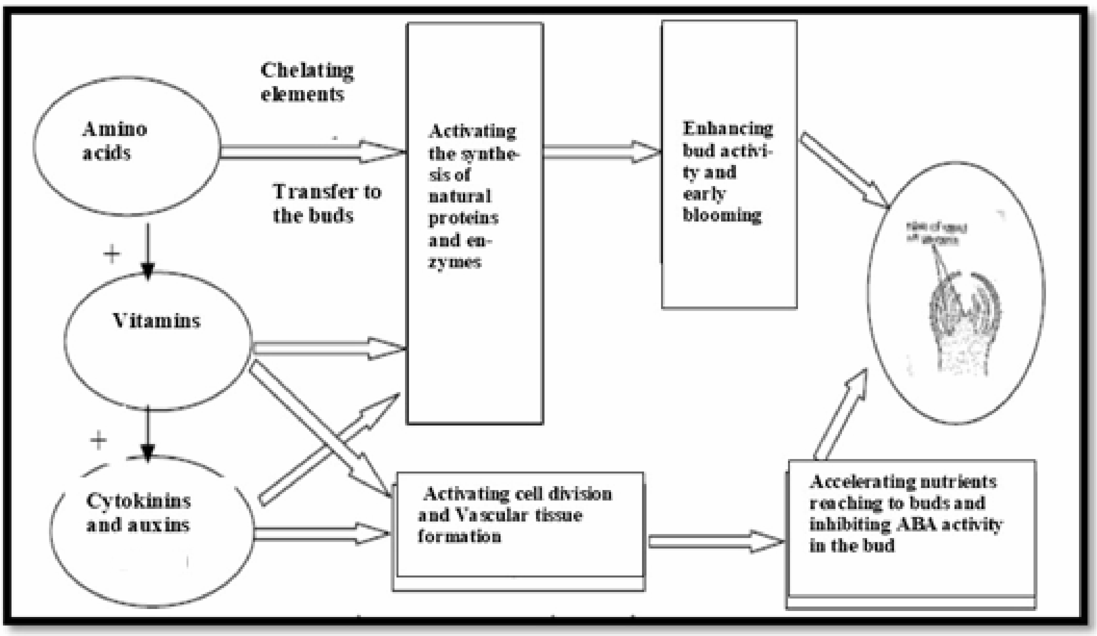
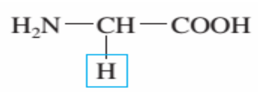
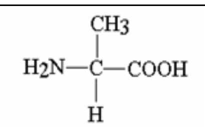
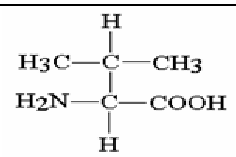
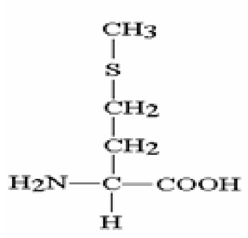
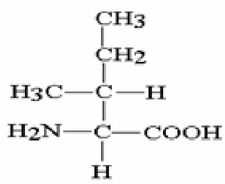
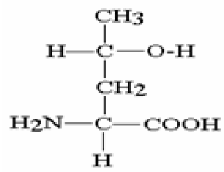
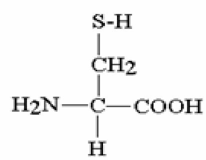
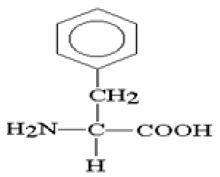
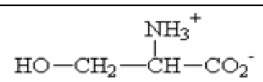
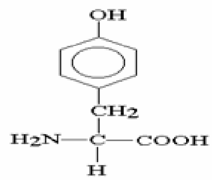
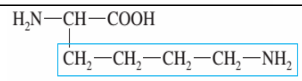
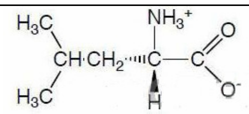
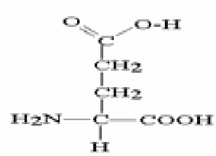
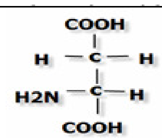
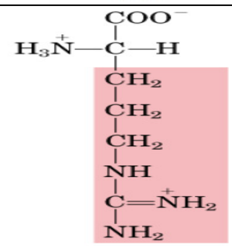
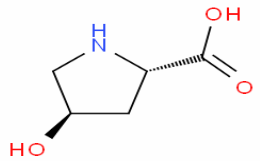
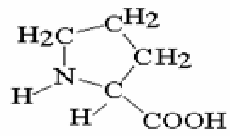
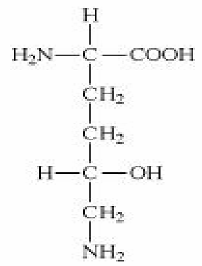
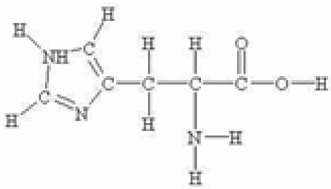
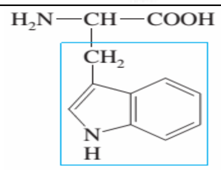


Fig. 2 : The role of amino acids in plants

Table 1: the role of amino acids and their structural formula.

Amino acid	Symbol	Amino acid role within plant	Formula	Molecular weight
Glycine	Gly	Activating photosynthesis and raising its efficiency as it enhances chlorophyll formation and encourages vegetative growth as well as it has a role in pollination and fruitfulness.		75
Alanine	Ala	Affecting plant growth velocity and activating chlorophyll formation		89
Valine	Val	Affecting the velocity of growth, root formation, and seed production.		117

Methionine	Met	Accelerates the fruit ripening as it enters the cycle of ethylene formation and has a role in the root activation.		149
Isoleucine	Lle	Increasing the shoot system, growth, and early yield		131
Thereonine	The	Increasing plant tolerance to diseases		119
Cysteine	Cys	Increasing vital processes and regulating them within plants and increasing the disease resistance		121
Phenylalanine	Phe	Improving plant cells and embryo formation		165
Serine	Ser	Increasing plant tolerance to diseases, activating chlorophyll, and has a role in hormone balance inside plant		105
Tyrosine	Tyr	Increasing plant tolerance to diseases		181
Lysine	Lys	Increasing the shoot system, growth, and early yield		146
Leucine	Leu			131
Glutamic Acid	Glu	Increasing the shoot system, growth, and early yield		147
Aspartic Acid	Asp	Enhancing plant resistance to diseases		133
Arginine	Arg	Increasing tolerance to the hard conditions such as heat, frost, drought, and salinity. It has a role in chlorophyll formation and enhancing root formation as well as cell division and poly amid formation (Hozayn and Abd El-Monem, 2010).		174

Hydroxy Proline	Hyp	Increasing tolerance to the hard conditions such as heat, frost, drought, and salinity.		
Proline	Pro	Increasing tolerance to the hard conditions, activating pollen grain germination, organizing osmosis potential, maintaining the colloidal properties of the cell protoplasm, and removing the negative effect of free radicals.		115
Hydroxy Lysine	Hyl	Increasing crop growth and early yield.		
Histidine		Increasing crop growth, early yield, and enhancing phosphorus action inside plant.		155
Tryptophan	Try	Helping to the formation of active auxins IAA necessary for plant growth and has a role in the early yield.		204

Effect of some amino acids on the root and shoot systems of Plant

Research results showed the positivity effect of amino acid on stimulating growth and increasing yield when they were used for many field crops. Studies illustrated that spraying amino acids on plants with increased both the vegetative growth and leaf area as they are easily absorbed by leaves to create protein and increase the leaf chlorophyll content resulting in improving the crop yield and quality (Mccarthy *et al.*., 1990; Lozek and Fecenko, 1996; Neri *et al.*, 2002). Dromantiene *et al.* (2013) reported that the absorption of amino acids by winter wheat plants did not depend on the chlorophyll activity as plants can use these materials directly and save the energy. Studies confirmed that amino acids can affect the physiological activities of plant growth and development directly or indirectly, however, they affect positively and greatly reduce the damages caused by non-biotic stresses (Kowalczyk and Zielony, 2008; Abd El-Aal *et al.*, 2010; Shalaby and El-Ramady, 2014). These studies were consistent with those of (Mohamed, 2006; Zaki *et al.*, 2007) who referred to the beneficial role of amino acids. Nikiforova *et al.* (2006) mentioned that spraying amino acids stimulated the emergence of the root system and activated the growth of plant parts above the soil surface. These results were confirmed by the findings of Kandi *et al.* (2016) who indicated that spraying a mixture of amino acids and nitrogen fertilizers at the levels (166, 214, and 262 $kgN.ha^{-1}$) on the wheat crop plants increased the plant height by 23.29% as well as the chlorophyll concentration leading to the highest degree of photosynthesis and increasing the grain yield by 7.50% and straw by 10.90%. These results were consistent with those of Ashoori *et al.* (2013) who referred to that spraying an amino acid compound at the concentration of $1gm.L^{-1}$ with chemical fertilizer 45 and 65 days after planting enhanced the plant functions. El-Naggar and El-Ghamry (2007) found that spraying 2000 $mg.L^{-1}$ of amino acids on wheat plants 55 and 75 days after sowing increased the number of tillers, plant height, and chlorophyll content, these results confirmed those of Meijer (2003) who reported that spraying amino acids on wheat plants stimulates plant growth and increases yield and protein content. Ramaih *et al.* (2003) and Kandil and Marie (2017) mentioned that Tryptophan is the major origin of IAA in most living organisms. Martens and Fankenberger (1994) and Sarwar and Frankenberger (1994) found that the treatment of spraying Tryptophan at $10^{-5}.L^{-1}$ 40 days after sowing wheat increased the growth rate. EL-Bassiouny (2005) reported that spraying 25, 50, and 100 $mg.L^{-1}$ of Tryptophan on wheat plants 30, 45, and 75 days after sowing increased the plant growth, where the concentration of 100 $mg.L^{-1}$ produced the highest plant height among them with no significant difference, while the concentration of 25 $mg.L^{-1}$ was superior in giving the highest number of $tillers.m^{-2}$ (605 $tillers.m^{-2}$), the highest leaf area (74.72 cm^{-2}), and the highest plant dry weight (1049 $g.m^{-2}$), however, this concentration did not differ significantly from 50 $mg.L^{-1}$ in the traits of the number of tillers and plant dry weight which were 583 $tillers.m^{-2}$ and 977 $g.m^{-2}$ respectively, while spraying 50 $mg.L^{-1}$ of Tryptophan achieved the highest dry weight of tillers (488$g.m^{-2}$), yet, the Tryptophan concentration did not affect the harvest index. He also indicated that spraying 50 $mg.L^{-1}$ of Tryptophan on wheat plants increased the content of chlorophyll a and b significantly, while the change in carotenoids content was insignificant. Results of El-Hosary *et al.* (2103) referred to an increment in all growth traits except for the traits of the number of tillers, plant height, number of leaves, plant dry weight, plant fresh weight, and flag leaf area as a result of foliar spray of Tryptophan and Cysteine at different concentrations where the treatment of spraying 50 $mg.L^{-1}$ of Tryptophan produced the highest number of tillers (6.01 and 7.56 $tillers.plant^{-1}$) and leaves (23.14 and 26.35 $leaves.plant^{-1}$) in two seasons respectively, in addition to the dry weight that was affected obviously by spraying Tryptophan at the concentration of 50 $mg.L^{-1}$ recording 17.76 and 23.00 $g.plant^{-1}$ in the two seasons respectively. The treatment of 50$mg.L^{-1}$ Tryptophan recorded the highest length of the spike in the second season (12.14 cm), whereas in the first season, the best concentration was 100 $mg.L^{-1}$ producing length spikes 9.43 cm in an average. The treatment of 150 $mg.L^{-1}$ Cysteine also recorded values of growth higher than the treatment of 100 $mg.L^{-1}$ of this amino acid. The results were also clarified that foliar application of the used concentrations of Tryptophan and Cysteine led to a significant increment in all wheat growth traits compared to the control treatment. He referred to the total photosynthesis pigments (chlorophyll a, chlorophyll b, and carotenoids) were increased significantly affected by used amino acids (Tryptophan at the concentrations 50 and 100 $mg.L^{-1}$ and Cysteine at 100 and 150 $mg.L^{-1}$). Tryptophan was more effective when it was used at the concentration 50 $mg.L^{-1}$ recoding averages 1.229, 0.6101, and 04390 $mg.g^{-1}$ for the chlorophyll a, chlorophyll b, and carotenoids respectively compared to the control treatment recoding 0.666, 0.3028, and 0.2219 $mg.g^{-1}$ respectively. This result confirmed what El-Nabarawy *et al.* (2001) reported the necessity of amino acids for chlorophyll synthesis. Results of Alaei (2011) showed increasing the chlorophyll content in wheat plants resulted in an increment in the grain yield which went in line with the findings of Abd- El-Aal *et al.* (2010) and Khayatnezhad *et al.* (2011) who referred that spraying amino acids on wheat plants increased chlorophyll a and b. Azevedo *et al.* (2006) noticed that the essential amino acids such as tryptophan and lysine make maturity early, activate chlorophyll and increase the amount of sugar. Results gotten by Zahir *et al.* (2005) and Sivasankari *et al.* (2005) referred that spraying 50 $mg.L^{-1}$ Tryptophan enhanced the root and vegetative growth of different crops. Khatid *et al.* (1999) found that spraying Tryptophan at 10^{-4} molars produced the highest plant height and number of tillers (99.60 cm and 545.00 tillers respectively) differing significantly from the control that produced the lowest values (93.60 cm and 491.00 tillers respectively), while the two concentrations 10^{-3} and 10^{-4} molar did not affect significantly the spike length, but they showed high spike length averaged 11.90 and 12.00 cm respectively compared to the control producing the lowest spike length (11.20 cm). Nilesh *et al.* (2012) referred to performing the best when spraying the high doses of cysteine (0.02%) 40 days after sowing that gave the highest number of tillers and plant height (301.12 and 306.46 $tillers.m^{-2}$) and (85.22 and 86.25 cm) in two seasons respectively with significant differences compared to the control treatment giving the lowest averages (250.39 and 255.19 $tillers.m^{-2}$) and (78.10 and 77.49 cm) respectively, however, results showed also that the differences within the same treatment were not significant; moreover, they mentioned that biological regulators are a group of chemical substances including cysteine, regulate plant activities such as physical and physiological activities. Many studies have been conducted to investigate the effect of biological regulators on the yield quantity and quality as well as on the seeds. According to Sharma *et al.* (2008), there was a significant improvement as a response to the foliar spray of biological regulators on wheat crop. Results of Govind *et al.* (2007) referred that biological regulators enhance the plant growth and photosynthesis efficiency; furthermore, they affect the transpiration rate and alleviate the stress effect (Freeha *et al.*, 2008), as well tolerate crop lodging. Results of Aldesuquy *et al.* (2012) illustrated that spraying Glycine betaine (GB) on wheat plants affected the yield and its components positively with a significant difference compared to the control treatment and was significantly superior in most growth traits including root system length, plant height, and spike length which they were averaged 68.85, 84.378, and 15.52 cm respectively compared to the control treatment producing 67.49, 82.66, and 15.17 cm respectively. Results of AL-Qaisi *et al.* (2016) referred that arginine increased the seed germination, germination velocity, germination stimulation indicator, and seed vigor, root system, as well as increased root system and seedling dry weight in maize significantly. Results of Dawood and Glaim (2018) showed that spraying 200mg. L^{-1} of arginine on maize increased the chlorophyll index, leaf area, and plant height significantly reaching 10.17, 18.73, 10.57, and 8.27% respectively. Results also showed that spraying 200 $mg.L^{-1}$ proline increased the mentioned traits by 15.34, 27.13, 14.80, and 14.60 % respectively. Haroun *et al.* (2010), when using 1, 2, 3, 4, and 5 ml of glutamic acid on *Phaseolus vulgaris* found that the two concentrations, 1 and 2 mL, increased all growth criteria. Results obtained by Mazher *et al.* (2011) who used 100 and 200 $mg.L^{-1}$ glutamic acid on *Codiaeum variegatum* L. plants showed that increasing the concentration to 200 $mg.L^{-1}$ increased the growth criteria (plant height, number of leaves, number of branches disk diameter, root length, plant dry weight, fresh weight, and the plant content of carbohydrates and N, P, and K) significantly. Results of Talat *et al.* (2013) explained the superiority of spraying 100 $mg.L^{-1}$ proline on two wheat varieties grown under the effect of saline stress in the traits, plant height, fresh weight, total chlorophyll content potassium concentration, sodium concentration, and transpiration rate, compared to the concentration of 50 $mg.L^{-1}$ furthermore the control, while the concentration 50$mg.L^{-1}$ was superior in the dry weight and water use efficiency.

Effect of some amino acids on the traits of yield and its components

Khatid *et al.* (1999) found that spraying 10^{-3} and 10^{-4} of Tryptophan on wheat plants increased the grain yield significantly reaching 3.34 and 3.39 $Mg.ha^{-1}$ as well as straw yield to be 7.24 and 7.35 $Mg.ha^{-1}$ compared to the control treatment giving the lowest averages of grain and straw yields (3.04 and 6.21 $Mg.ha^{-1}$) for both concentrations respectively. The concentration 10^{-4} gave the highest weight of 1000 grains (36.60g) differing significantly from control treatment producing the lowest weight (34.90 g). The two Tryptophan concentrations 10^{-3} and 10^{-4} M L^{-1} did not affect the number of spikelets significantly, yet they produced 17.30 and 17.60 $spikelets.spike^{-1}$ respectively. EL-Bassiouny (2005) reported that spraying Tryptophan at the concentrations 25, 50, and 100 $mg.L^{-1}$ 30, 45, and 75 days after sowing wheat increased the grain yield where the treatment of 50 mg.L^{-1} the highest value of 1000 grains (42.89g), grain yield (4.840 Mg.ha^{-1}), and straw yield (8.609 Mg.ha^{-1}), while spraying Tryptophan did not affect the harvest index. El-Naggar and El-Ghamry (2007) referred that spraying 2000 mg.L^{-1} amino acids 55 and 75 days after sowing increased the number of grains, the weight of 1000 grains, grain yield, and straw yield. He confirmed the findings of (Meijer, 2003; Abd El-Aal, *et al.* 2010; Khayatnezhad *et al.*, 2011; Alaei, 2011) who reported that spraying amino acids on wheat plants increased the traits of yield and its components. Rūta *et al.* (2011) suggested that spraying amide nitrogen contained different concentrations of amino acids (0-3 %) at the milk maturity stage increased the grain yield by 0.16 – 0.53%. The liquid fertilizer treatment of nitrogen contained 1.5% amino acids gave the highest grain yield averaged 6.46 Mg.ha^{-1}. He reported also that wheat crop correlated significantly to the concentration of amino acids in the liquid fertilizer of amide nitrogen. Result of Nilesh *et al.* (2012) referred to the best performance getting from spraying high concentration of cysteine (0.02%) on wheat plants 40 days after sowing reflecting on many traits including, the highest grain yield (6.15 and 5.70 Mg.ha^{-1}) in two seasons respectively and the highest number of grains in the second season (53.40 grain.spike^{-1}) differing significantly from the control treatment that produced the lowest values (4.52 and 4.60 Mg.ha^{-1}) and (48.40 and 49.20 grain. Spike^{-1}) in the two seasons respectively. The results obtained by the same researchers didn't refer to a significant difference within the same treatment. Results of Aldesuquy *et al.* (2012) illustrated that spraying Glycine betaine (GB) on wheat plants affected the yield and its components positively causing significant differences compared to the control treatments as a response for using bio-stimulators. Grain yield correlated strongly to the yield components (including, spike dry weight, number of spiklets, number of grains per spike weight of 1000 grains, grain yield, biological yield, and harvest index) which were superior (3.17 g, 17.33 spikelets. Spike^{-1}, 54.33 grains.spike-1, 4.65 g, 3.92g, 8.14g, and 0.96% respectively) compared to the control treatment values (3.07g, 17.01 spikelets. Spike^{-1}, 53.17 grains.spike^{-1}, 4.59g, 3.63g, 7.87g, and 0.85% respectively). Results of El-Hosary *et al.* (2013) demonstrated that wheat plants foliar sprayed with 50 mg.L^{-1} Tryptophan produced the highest number of spikes (3.92 and 5.56 spikes.plan^{-1}) spike dry weight (4.39 and 6.42 g), grain weight (2.85 and 5.18 g), number of grains per spike (55.48 and 69.44 grains.spike^{-1}), and grain yield (2.59 and 3.02 Mg.ha^{-1}) in the two seasons respectively. The treatment of spraying 150 mg.L^{-1} Cysteine also recorded the highest values for most traits of yield and its components compared to the concentration 100mg.L^{-1}. The results obtained by the researchers also showed that spraying all used concentrations of tryptophan and cysteine on wheat plants increased all traits of yield and yield components significantly compared to the control treatment. Results of Dromantiene *et al.* (2013) showed that spraying nitrogen fertilizers containing 0.5–3.0% amino acids on winter wheat crop at the stage of ear emergence increased the grain yield to 0.13 – 0.37 Mg.ha^{-1}. Results obtained by Hammad and Ali (2014) reported that treating wheat plants with 3mg.L^{-1} amino acids increased the grain yield by 20.49% compared to untreated plants. Results of Zahir *et al.* (2005) and Sivasankari *et al.* (2014) showed that spraying 50mg.L^{-1} tryptophan improved yields of different crops. Results of Dawood and Glaim (2018) illustrated that spraying 200 mg.L^{-1} proline on maize increased the plant yield per by 17.35% and spraying 2000 g.L^{-1} arginine increased the plant yield by 16.35%. Results of Baqir and AL-Naqeeb (2019) Showed that Spraying 50mg L^{-1} tryptophan improved yield of wheat and its Componenets number of spikes (477.00 and 944.67 spikes m^{-2}) weight of 1000 grains (32.01 and 33.55 g) and yield (5.77 and 5.33 mg ha^{-1}) in the two seasons. Results of AL- Hamoudi (2011) showed the proline role in increasing the yield of wheat growing under adverse conditions (water stress) when it was sprayed at concentrations 20 and 40 mg.L^{-1} at three levels of water stress (100, 50, and 25% of the field capacity) where 20 mg.L^{-1} proline was significantly superior. Results of Hasan (2012) referred to the superiority of spraying 75mg.L^{-1} proline on the mung bean plants affected by periods of thirsting compared to the other used concentrations (25 and 125 mg) and to the control treatment.

Effect of some amino acids on some qualitative traits of grains

The quality of good grains is an important component of food production. The quality of wheat grains depends on the chemical, biological and physiological processes that take place in the plant during the developmental stages, and partly on genetic factors and on a number of environmental factors during the vegetative growth phase (Johansson *et al.*, 2003; Svec *et al.*, 2006; Лёвкин *et al.*, 2007). Results of Mccarthy *et al.* (1990) and Lozek Fecenko (1996) and Neri *et al.* (2002) referred to the positive role of amino acids in enhancing the plant yield quality. EL-Bassiouny (2005) found an increment in the protein content by 18.52 % resulted from spraying 50 mg.L^{-1} tryptophan, in attrition to carbohydrate percentage increasing by 64% when 100 mg.L^{-1} was used. These results confirmed those referred to by Landry and Delhaye (1993) and Arshad *et al.* (1995) and Hegazi *et al.* (1995). Alaru *et al.* (2003) and Meijer *et al.* (2003) reported that spraying amino acids on wheat crop plants stimulated protein synthesis. Dromantiene *et al.* (2009) recorded an enhancement in the wheat grain quality resulted from spraying 30kg.L^{-1} liquid fertilizers of nitrogen amide containing 0-3% amino acids at the booting stage where the protein content increased from 0.63% to 0.73%. Rūta *et al.* (2001) confirmed that spraying liquid fertilizer of nitrogen amide containing 0-3% amino acids at the milk maturity stage increased the protein content in grains from 0.52% to 0.87%. Results of Aldesuquy *et al.* (2012) showed that the treatment of Glycine betaine (GB) increased significantly the protein content in wheat grains. Nilesh *et al.* (2012) found that the treatment of foliar spray of 0.01-0.02% cysteine on the wheat plants 40 days after sowing enhanced the grain quality. Results of Dromantiene *et al.* (2013) showed that foliar fertilization of amide nitrogen containing 0.5- 2.0% amino acids at the stage of spike emergence enhanced the wheat grain quality where the protein content increased by 0.62 – 0.81% compared to the control and the highest protein percentage was 13.96% found in the winter wheat sprayed by amide nitrogen containing 0.5% Amino acids; moreover, the gluten values increased by 1.1–1.7% as a result of amino acid fertilization. The correlation and regression analysis referred to a significant correlation (r= 0.70) between amino acids and protein content in the winter wheat grains.

References

Abd EL-hafez, A.A.Y. (2011). Use of amino acids in improving the Quatity and performance of horticultural

Crops under Egyptian Conditions. Academy of Sci. Res. J. of Sci . 413.

Abd El-Aal, F.S.; Shaheen, A.M.; Ahmed, A.A. and Mahmoud, R. (2010). Effect of foliar application of urea and amino acids mixtures as antioxidants on the growth yield and characteristics of squash. Res J Agric Biol Sci., 6 (5): 583- 588.

Abed, A.K.M. (2007). Study of amino acids and fatty acids in date plant fruit *Phoenix dactylifera* L. Cultivars ALdehin and brain of three male date plant pollinaters. J. of Basrah Res. Sci., 31(3): 31-37.

Abu-Dahi, Y. M. and Al-Younis, M.A. (1988). Plant Nutrition. Hand book Ministry of Higher Education and Scientific Research. Univ. of Baghdad. 411.

Ahmed, A.H. and Abd El-Hameed, H.M. (2003). Growth uptake of some nutrients and productivity of Red Roomy vines as affected by spraying of some amino acids, magnesium and boron. Minia J. of Agric. Res. Develop., 23(4): 649-666.

Ahmed, F.F.; Abdelaal Salah, A.H.M.; El-Masry, E.M.A. and Farag, W.B.M.M. (2014). Response of superior grapevines to foliar application of some micronutrients, calcium, amino acids and salicylic acids. World Rural Observ. 6(3):57-64.

Ahmed, F.F., Mohamed, M.A.; Abd ElAal, A.M.K. and Amin, M.M. (2007). Response of Red Roomy grapevines to application of amino acids and some micronutrients. The third Conf. of Sustain Agric. And Develop. Fac. of Agric. Fayoum Uni., 150-170.

AL-Hamoudi, M.A.A. (2011). Response of Four wheat Cultivars *Treaticum aestivum* L. For Application proline Concentration under different water Stress Level. Thesis .Coll. of Ednca. Sci. Univ. of kerbala.

Alaei, Y. (2011). The Effect of amino acids on leaf chlorophyll content in bread wheat genotypes under drought stress conditions .Middle-East J. Sci. Res., 10(1): 99-101.

Alaru, M.; Laur, U. and Jaama, E. (2003). Influence of nitrogen and weather conditions on the grain quality of winter triticale. Agronomy Research, 1: 3–10.

Aldesuquy, S.H.; Abbas, M.A.; Abo-Hamed, S.A.; Elhakem, A.H. and Alsokari, S.S. (2012). Glycine betaine and salicylic acid induced modification in productivity of two different cultivars of wheat grown under water stress. J. of Stress Physi and Bioch., 8(2): 72-89.

AL-Modhafer, S.AM. (2009). Biochemistry. Dar ALmaserah for pnblishing, distribntion and printing. Oman, 430.

AL-Qaisi, F.W.A.; Mahdi, T.S. and Mahmud, R.W. (2016). Effect of hydrogen peroxide and arginine in seeds germination and seedling growth of Zea mays and Surface growth of *Fusarium moxysporum*. J. of AL-Mustansiriyah.Sci.27 (4): 17-21.

Al-Said, M.A. and Kamal, A.M. (2008). Effect of folair spray with folic acid and some amino acids on flowering yield and quality of sweet pepper. J. Agric. Sci. Mansoura Univ., 33(10): 7403 - 7412.

Arshad, M.; Hussain, A. and Shakoor, A. (1995). Effect of soil applied L–tryptophan on growth and chemical composition of cotton. J. Plant Nutr., 18: 317–329.

Ashmead, H.D. (1986). The Absorption Mechanism of Amino Acid Chelates by Plant Cells. In: Foliar Feeding of Plants With Amino Acid Chelates (Ashmead, H.D.; H.H. Ashmead; G.W. Miller and H.H. Hsu, Noyes Publications, Park Ridge, New Jersey, USA, 219-235.

Ashoori, M.; Esfehani, M.; Abdollahi, S. and Rabiei, B. (2013). Effects of organic fertilizer complements application on grain yield, nitrogen use efficiency and milling properties in two rice cultivars *Oryza sativa* L. Iranian J. Field Crop Sci., 43: 701-713.

Azevedo, R.A.; Lancien, M. and Lea, P.J. (2006). The aspartic acid metabolic pathway, an exciting and essential pathway in plants. Amino Acids, 30(2): 143–162.

Baqir, H.A. and AL-Naqeeb, M.A.S. (2019). Effect of Some amino acids tillering and yield of three bread what cultivars. Iraqi. J. Agric. Sci 50: 20-30.

Beavers, L. (1991). Nitrogen Metabolism in Plant. Hand book (Translator) Ministry of Higher Education and Scientific Research. Univ.of Baghdad. 477.

Coccoti, S.P. (1996). Fertilizer Research. 43:117-125. (Cited from Zhao, F.Y., P.Y.A. Withers, E.J. Evans, J.Monaghan, S.E. Salmon, P.R.Shewry and S.P. McGrath. 1997. Plant Nutrition for sustainable Food Production and Environment, 917-922, Tokyo, Japan.

Dawood, W.M and Glaim, A.A. (2018). Response of growth traits and grain yield of *Zea mays* L. to spray by prolin and Arginine Diyalay. of Agri. Sci. 2(10): 129-136.

Dreccer, M.F.; Oijen, M. and Schapendonk, A. (2000). Dynamics of vertical leaf nitrogen distribution in a vegetative wheat. Impact on canopy photosynthesis. Annals of canopy Botany, 86: 821–831.

Dromantiene, R.; Pranckietene, I.; Šidlauskas, G.; and Pranckietis, V. (2013). Changes in technological properties of common wheat *Triticum aestivum* L. grain as inflenced by amino acid fertilizers J. Zemdirbyste-Agric. 100(1):57-62.

Dromantiene, R.; Pranckietiene, I.; Sidlauskas, G. and Pranckietis, V. (2009). The effect of fertilisers containing amino acids on winter wheat grain yield and technological properties. J. Zemd. Agric. 96(4): 97–109.

Edrees, MH. (2009). Plant Physiology Encyclopedia of the plant. Suzan Mnbarak Scientific Exploration Center in Qario. Egypt. www.Smsec.com.

EL-Bassiouny, H.M.S. (2005). Physiological responses of wheat to salinity alleviation by nicotinamide and tryptophan. Int. J. Agric. Biol., 7(4): 653-659.

El-Ghamry, M.; Abd El-Hai, K.M. and Ghoneem, M. (2009). Amino and humic acids promote growth, yield and disease resistance of faba bean cultivated in clayey soil. Aust. J. of Basic and Appl. Sci, 3(2): 731-739.

El-Hosary, A.A.G.Y.; El-Morsi, A.; Hassan, E.A.; El-Awadi, M.E. and Abdel-Baky, Y.R. (2013). Effect of some bio regulators on growth and yield of some wheat varieties under newly cultivated land conditions. New York Sci. J. 6(6): 310-334.

El-Nabarawy, M.A. (2001). Mitigation of dark induced senescence. 1–By some amino acids. Ann. Agric. Sci. Moshtohor 39(1): 225–232.

El-Naggar, E.M. and El-Ghamry, A.M. (2007). Effect of bio and chemical nitrogen fertilizers with foliar of humic and amino acids on wheat. J. Agric. Sci. Mansoura Univ., 32(5): 4029-4043.

El-Shabasi, M.S.; Mohamed, S.M. and Mahfouz, S.A. (2005). Effect of foliar spray with some amino acids on growth, yield and chemical composition of garlic plants. The 6 th Arabian Conf. for Hort., Ismailia, Egypt.

Freeha, A.; Abdul, W.; Farrukh, J. and Muhammad, A. (2008). Influence of foliar applied thiourea on flag leaf gas exchange and yield parameters of bread wheat *Triticum aestivum* L. cultivars under salinity and heat stresses. Int. J. of Agri. and Biol., 10(6): 619-626.

Govind, R.N.K.; Nathawat, N.S.; Nair, J.S.; Sharma, H.R.; Kumawat, S.M.; Sahu, M.P. and D'Souza, S.F. (2007). Effect of seed soaking with sulphydryl compounds on the photochemical efficiency and antioxidant defence system during the growth of pearl millet under water limiting environment. Photosynthetica 45(3): 477-480.

Hammad, S.A.R. and Ali, O.A.M. (2014). Physiological and biochemical studies on drought tolerance of wheat plant by application of amino acids and yeast extract. Annals of Agri. Sci., 59(1): 133-145.

Haroun, S.A.; Shukry, W.M. and El-Sawy, O. (2010). Effect of asparagine or glutamine on growth and metabolic changes in *phaseolus vulgaris* under *in vitro* conditions Bioscience Research, 7(1): 01-21.

Hasan, R.H. (2012). Effect of Proline Acid on Tolerance of Mung bean plant *Vigna radiate* L. to Drought Duration. Thesis. Coll. of Ednc.Ibn AL-Haitham. Uni. of Baghdad.

Havlin, J.L.; Beaton, J.D.; Tisdale, S.L. and Nelson, W.L. (2005). Soil Fertility and Fertilizers. An Introduction to Nutrient Management. Sevennth Edition. 515.

Hegazi, A.M.; Ebad, F.A.; El–Gaaly, F.M. and Nour El–Din, N.M. (1995). Interacting effect of salinity and growth regulators on some chemical composition of wheat plants. Annal Agric. Sci., (Moshtohor), 33: 659–68.

Hozayn, M. and Abd El-Monem, A.A. (2010). Alleviation of the potential impact of climate change on wheat productivity using arginine under irrigated Egyptian agriculture. Option Mediterraneenes A No., 95: 95-100.

Johansson, E.; Prieto-Linde, M.L.; Svensson, G. and Jonsson, J.O. (2003). Influences of cultivar, cultivation year and fertilizer rate on amount of protein groups and amount and size distribution of mono- and polymeric proteins. J. Agri. Sci, 140: 275–284.

Kamar, M.E. and Omar, A. (1987). Effect of nitrogen levels and spraying wih aminal-forte (amino acids salvation) on yield of and potatoes. J. Agric. Sci. Mansoura Univ., 12(4): 900 - 907.

Kandi, A.A.; Sharief, A.E.M.; Seadh, S.E. and Altai, D.S.K. (2016). Role of humic acid and amino acids in limiting loss of nitrogen fertilizer and increasing productivity of some wheat cultivars grown under newly reclaimed sandy soil .Int. J. Adv. Res. Biol. Sci. 3(4): 123-136.

Kandil, E.E. and Marie, E.A.O. (2017). Response of some wheat cultivars to nano-, mineral fertilizers and amino acids foliar application. Alex Sci exch. J. 38(1): 53-68.

Khatid, M.; Zahir, Z.A.; Waseem, A. and Arshad, M. (1999). Azotobacter and L-tryptophan Application for Improving Wheat Yield. Pakistan J. of Biol. Sci, 2 (3): 739-742.

Khayatnezhad, M.; Gholamin, R.; Jamaati-eSomarin, S.H. and Zabihie-Mahmoudabad, R. (2011). The leaf chlorophyll content and stress resistance relationship considering in Corn cultivars *Zea mays* Adv. Environ. Biol., 5(1): 118-122.

Kowalczyk, K. and Zielony, T. (2008). Effect of aminoplant and asahi on yield and quality of lettuce grown on rockwool. Proc. Conf. of Biostimulators in Modern Agri, 7-8 Febuary, Warsaw, Poland.

Landry, J. and Delhaye, S. (1993). The tryptophan contents of wheat, maize and barley grains as a function of nitrogen content. J. Cereal Sci., 18: 259–66.

Lozek, O. and Fecenko, J. (1996). Effect of foliar application of manganese, boron and sodium humate on the potato production. Microelementy Wrolinctwie. 1: 169-172.

Madian, A.M. and Refaai, M.M. (2011). The synergistic effect of using B vitamins with two amino acids tryptophane and methionine in Thompson seedless grapevines. Minia J. of Agric. Res. & Develop 31(1): 100-121.

Martens, D.A. and Fankenberger, W.T.J. (1994). Assimilation of exogenous 2' – 14C – indole –3 –acetic acid and 3' – 14C tryptophan exposed to the roots of three wheat varieties. plant and Soil, 166: 281–290.

Mazher, A.A.M.; Sahar, M.Z.; Safaa, A.M. and Hanan, S.S. (2011). Stimulatory Effect of Kinetin, Ascorbic acid and Glutamic Acid on Growth and Chemical Constituents of *Codiaeum variegatum* L. Plants. American-Eurasian J. Agric. & Environ. Sci., 10(3): 318-323.

Mccarthy, P.; Clapp, C.E. and Malcolm, R.L. (1990). Humic substances in soil and crop sciences: Selected reading. American Society of Agronomy and Soil, Sci Soc of Amer, Madison, Wisconson. 261-271.

Meijer, A.J. (2003). Amino acids as regulators and components of non proteinogenic pathways. The J. of Nut. 133: 2057–2062.

Mengel, K. and Kerby, E.I. (1984). Principles of plant Nutrition (trans lated) Ministry of Higher Education and Scienti fic Research, University. of Mosel., 776.

Mohamed, A.M. (2006). Effect of Some Bio-chemical Fertilization Regimes on Yield of Maize. M.Sc. Thesis, Fac. of Agric., Zagazig Univ., Egypt, 70–177.

Näsholm, T.; Huss-Danell, K. and Hogberg, P. (2000). Uptake of organic nitrogen in the field by four agriculturally important plants pecies. Ecol., 81(4): 1155–1161.

Neri, D.; Lodolini, E.M.; Chelian, K.; Bonanomi, G. and Zucconi, F. (2002). Physiological responses to several organic compounds applied to primary leaves of cowpea *Vigna sinensis* L. Acta Hort (ISHS) 594: 309-314.

Nikiforova, V.J.; Bielecka. M.; Gakiere, B.; Krueger, S.; Rinder, J.; Kempa, S.; Morcuende, R.; Scheible, W.R.; Hesse, H. and Hoefgen, R. (2006). Effect of sulfur availability on the integrity of amino acid biosynthesis in plants. Amino Acids, 30(2): 173–183.

Nilesh, G.; Chakrborti, P.; Rai, A.K. and Gupta, P.C. (2012). Effect of Plant growth regulator on growth response and yield component in wheat *Triticum aestivum* L. Crop Res. J .of Agric/ Sci., 3(1): 204-208.

Persson, J. and Näsholm, T. (2002). Regulation of amino acid uptake in conifers by exogenous and endogenous nitrogen. Planta, 215: 639–644.

Ramaih, S.; Guedira, M. and Paulsen, G.M. (2003). Relationship of indoleacetic acid and tryptophan dormancy and pre harvest sprouting of wheat. Funct. Plant Biol., 30: 939–945.

Rūta, D.; Irena, P.; Gvidas, S.; Viktoras, P. and Sandra, G. (2011). The Effect of amino acids fertilizers on winter wheat grain productivity and quality. Proceedings of the International Sci. Conf. Rural Dev; 5 (2): 178.

Sarwar, M. and Frankenberger, W.T. (1994). Influence of L–tryptophan and auxin applied to the rhizosphere on the vegetative growth of *Zea mays* L. Plant and Soil, 160: 97–104.

Shafeek, M.R.; Helmy, Y.I.; Shalaby, M.A.F. and Omer, N.M. (2012). Response of onion plants to foliar application of sources and levels of some amino acid under sandy soil conditions. J. of Appl. Sci. Res, 8(11): 5521-5527.

Shalaby, T.A. and El-Ramady, H. (2014). Effect of foliar application of bio-stimulants on growth, yield, components, and storability of garlic *Allium sativum* L. AJCS 8(2): 271-275.

Sharma, K.M.; Sharma, D.D.; Shuk, K.B. and Upadhyay, B. (2008). Growth partitioning and productivity of wheat as influenced by fertilization and foliar application of bioregulators. Indian J. Plant Physio. 13(4): 387-393.

Sharma-Natu, P. and Ghildiyal, M. (2005). Potential targets for improving photosynthesis and crop yield. Current Sci, 88(12): 1918–1928.

Sivasankari, B.; Anandharaj, M. and Daniel, T. (2014). Effect of PGR producing bacterial strains isolated from vermisources on germination and growth of *Vigna unguiculata* (L.) Walp. J Biochem Tech 5(4): 808-813.

Svec, I.; Hruškova, M. and Jirsa, O. (2006). Evaluation of winter wheat varieties from three harvest years. Getreidetechnologie, 60: 78–86.

Talat, A.; Nawaz, K.; Hussian, K. and Bhatti, K.H. (2013). Foliar application of proline for salt tolerance of two wheat (*Triticum aestivum* L.) cultivars.World Appl. Sci. J. 22(4): 547-554.

Vernieri, P.; Borghesi, E.; Ferrante, A. and Magnani, G. (2005). Application of biostimulants in flating system for improving rocket quality. J. of Food, Agric. and Environ, 3: 86–88.

Yassen, B.T. (2001). Basics of plant physiologe DrAsharq printing. Univ. of Qatar.Do

Zahir, Z.A.; Asghar, H.N.; Akhtar, M.J. and Arshad, M. (2005). Precursor (L-tryptophan)-inoculum (Azotobacter) interaction for improving yields and nitrogen uptake of maize. J. Plant Nutr. 28(5): 805-817.

Zaki, N.M.; Hassanein, M.S. and Gamal El-Din, K.M. (2007). Growth and yield of some wheat cultivars irrigated with saline water in newly cultivated land as affected by biofertilization. J. Appl. Sci. Res. 3(10): 1121–1126.

Лёвкин, В.Н. (2007). Fertilizers and grain quality of winter wheat in light soil in the Volgograd .n Аграрный вестник Урала, 5(41): 31–33.