Journal of Applied Sciences

ISSN 1812-5654

OPEN ACCESS Journal of Applied Sciences

ISSN 1812-5654
DOI: 10.3923/jas.2019.811.817

Research Article
Physiological Response of Two Wheat Cultivars Grown under Sandy Soil Conditions to Aspartic Acid Application

Mohamed El-Sayed El-Awadi, Mervat Shamon Sadak, Kowther Gad Ali El-Rorkiek and Mona Gergis Dawood

Department of Botany, National Research Centre, Dokki, P.O. Box 12622, Cairo, Egypt

Abstract
Background and Objective: Wheat is one of the most important cereal crops grown in the world. The main amino acids synthesized by plants are glutamic acid and aspartic acid and from these two amino acids, the other amino acid may be formed. This study aimed to investigate the physiological role of aspartic acid in improving quality and productivity of two wheat cultivars grown under sandy soil conditions. **Materials and Methods:** A field experiment was carried out at the experimental Station of National Research Centre, Nubaria district, El-Behrea Governorate-Egypt, during two winter seasons of 2016/2017 and 2017/2018. Wheat grains cultivars (Benisuif 4 and Sohag 3) were obtained from Agricultural Research Centre Giza, Egypt. The experimental design was complete randomized block design with four replications. Foliar application of aspartic acid (0, 50, 75 and 100 mg L^{-1}) was carried out twice, plants were sprayed after 45 and 60 days from sowing. **Results:** It was noted that Benisuif 4 cv. was characterized by higher significant growth parameters, photosynthetic pigments, grains, straw and biological yield than Sohag 3 cv. when grown under sandy soil conditions. Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused marked significant increases in all growth parameters under investigation, photosynthetic pigments, yield and yield components, quality of the yielded grains (carbohydrate, protein, N, P, K contents) in both wheat cultivars. It is worthy to mention that 75 mg L^{-1} was the most pronounced treatment in increasing quality and productivity of two wheat cultivars grown under sandy soil conditions. **Conclusion:** It was concluded that aspartic acid treatments (50, 75 and 100 mg L^{-1}) increased quality and quantity of two wheat cultivars grown under sandy soil conditions, especially 75 mg L^{-1} was the most pronounced treatment.

Key words: Aspartic acid, *Triticum aestivum* L., cultivars, photosynthetic pigments, chemical composition

Citation: Mohamed El-Sayed El-Awadi, Mervat Shamon Sadak, Kowther Gad Ali El-Rorkiek and Mona Gergis Dawood, 2019. Physiological response of two wheat cultivars grown under sandy soil conditions to aspartic acid application. J. Applied Sci., 19: 811-817.

Corresponding Author: Mona Gergis Dawood, Department of Botany, National Research Centre, Dokki, P.O. Box 12622, Cairo, Egypt
Tel: (+202)33370933)

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops grown in the world. Grain yield of wheat is affected by many factors, of which cultivar, nitrogen fertilizer and amino acids application that play an important role in determining productivity of wheat. In addition, the quality of wheat yield depends on physiological-biochemical processes, which occur in plants during ontogenesis. They are partly determined by inherent indicators and a number of environmental factors during vegetation[1,2].

Amino acids (bio-stimulants) are organic nitrogenous compounds and building blocks in the synthesis of proteins and enzymes[3] and known as growth factors of higher plants[4]. Moreover, the importance of amino acids came from their widely use for the biosynthesis of a large variety of non-proteinic nitrogenous materials, i.e., pigments, vitamins, coenzymes, purine and pyrimidine bases. Moreover, amino acids treatments may reduce the application of fertilizers and improve quality of some plants via increasing plant mineral uptake and improving nutrients use efficiency[5]. Experiments showed that amino acids, which were used for plant fertilization, promoted the processes of plant respiration, photosynthesis and water cycle. In addition, amino acids increased concentration of ascorbic acid and accelerated protein synthesis. Moreover, promoted plant growth and yield formation[6,7]. For instance, it was indicated that amino acid application increased the growth parameters of tomato plants grown under salinity levels[8].

The main amino acids synthesized by plants are glutamate and aspartate and from these two amino acids the other amino acids may be formed. In young plants, amino acid biosynthesis is regulated by metabolism of glutamine, glutamate, aspartate and asparagine which is then converted into all other amino acids by various biochemical processes[9]. Asparagine and glutamine are highly efficient in promoting growth, yield and its components in faba bean[10] and snap bean[11]. The potent impact of aspartic acid on various areas of plant structure and function have prompted many investigators to apply them to several crops aiming to control growth patterns and development coupled with enhanced systemic resistance to various harmful agents. Glutamine and asparagine stand out for being the first amino acid in which the nitrogen absorbed by the plants is incorporated and from it a range of amino acids can be obtained through the activity of amino-transferases[12,13]. Exploiting and increasing wheat production in newly reclaimed sandy soil is necessary to bridge the gap between production and consumption of wheat. Therefore, improving both quantitative and qualitative characteristics of wheat were still the aim of many investigators. This study aimed to investigate the physiological role of aspartic acid in improving quality and productivity of two wheat cultivars grown under sandy soil conditions.

MATERIALS AND METHODS

Experimental procedure: A field experiment was carried out at the experimental Station of National Research Centre, Nubaria district, El-Behrea Governorate, Egypt, during two winter season of 2016/2017 and 2017/2018. Wheat grains cultivars (Benisuif 4 and Sohag 3) were obtained from Agricultural Research Centre Giza, Egypt. The experimental design was a complete randomized block design with four replications. Wheat grains were sown on the 15th November in both season in rows 3.5 m long and the distance between rows was 20 cm apart, plot area was 10.5 m^2 (3.0 m in width and 3.5 m in length). The recommended agricultural practices of growing wheat grain were applied and the seeding rate was 60 kg grains/fed. Pre-sowing, 150 kg/fed calcium super-phosphate (15.5% P_2O_5) was applied to the soil. Nitrogen was applied after emergence in the form of ammonium nitrate 33.5% at rate of 75 kg/fed was applied at five equal doses before the 1st, 2nd, 3rd, 4th and 5th irrigation. Potassium sulfate (48.52% K_2O) was added at two equal doses of 50 kg/fed, before the 1st and 3rd irrigations. Foliar application of aspartic acid (0, 50, 75 and 100 mg L^{-1}) was carried out twice, plants were sprayed after 45 and 60 days from sowing.

Data recorded at vegetative growth stage: Plant samples were taken after 75 days from sowing for measurements growth characters were measured in terms of shoot height (cm), number of leaves/tiller as well as tiller fresh and dry weight/plant (g). Photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) in fresh leaves were determined as method recommended in previous study by Moran[14].

Data recorded at harvest: At harvest the following characters were recorded on random samples of plants in each treatment to estimate the following characters: spike length, number of spikelet/spike, straw yield (t/feddan), biological yield (t/feddan) and grain yield (ardabe/feddan). The yielded grains were cleaned and used for determination of carbohydrates, proteins, nitrogen, potassium and phosphorous contents.

Chemical analysis: Total carbohydrates were determined according to the already published method[15]. Mineral contents of wheat grains (N, P, K) were determined according to previously used method[16] using a flame photometer. Protein contents were calculated by multiplying N% by 5.75.

Statistical analysis: Data were statistically analyzed by using the least significant difference at 5% level of probability (ANOVA- ONE WAY)[17].

RESULTS

Vegetative growth parameters: It was noted that control treatment of Benisuif 4 cv. was characterized by higher significant growth parameters (shoot height, as well as tiller fresh and dry weight) than Sohag 3 cv. when grown under sandy soil conditions (Table 1). Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused significant increases in most of growth parameters under investigation in both wheat cultivars. It is worthy to mention that 75 mg L^{-1} was the most pronounced treatment in increasing all growth parameters under investigation of both cultivars except shoot height and fresh weight of tiller of Benisuif 4 cv. that showed maximum increase by aspartic acid treatment at 50 mg L^{-1}.

Photosynthetic pigments: It was noted that Benisuif 4 cv. was characterized by higher photosynthetic pigments than Sohag 3 cv. either under control or aspartic acid treatments (Table 2). Regarding to enhancement effect of aspartic acid treatments on photosynthetic pigments, it was noted that 75 mg L^{-1} aspartic acid was the most pronounced treatment in increasing all components of photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoid) of both cultivars.

Grain yield and yield components: It was noted that Benisuif 4 cv. was characterized by higher yield components than Sohag 3 cv. as shown in Table 3. In addition, data in Table 3 shows the significant enhancement effect of aspartic acid treatments on yield and yield components (spike length, number of spikelet/spike, straw yield (t/feddan), biological yield (t/feddan) and grain yield (ardabe/feddan) in both cultivars when grown under sandy soil conditions. Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused significant increases in all yield parameters under investigation in both wheat cultivars. Regarding Benisuif 4 cv. and Sohag 3 cv. Aspartic acid at 75 mg L^{-1} was the most pronounced treatment.

Chemical composition of the yielded grains: It was noted that control treatment of Benisuif 4 cv. was characterized by higher carbohydrate and potassium contents in the yielded

Table 1: Effect of aspartic acid treatments on vegetative growth parameters of two wheat cultivars

Treatments	Shoot height (cm)	Number of leaves/tiller	Fresh weight of tiller (g)	Dry weight of tiller (g)
Benisuif 4 cv.				
Control	66.88	4.48	4.55	1.78
Asp 50 (mg L^{-1})	76.20	7.60	6.22	1.78
Asp 75 (mg L^{-1})	73.60	7.90	5.99	1.86
Asp100 (mg L^{-1})	70.18	6.82	5.80	1.69
Sohag 3 cv.				
Control	64.12	4.94	4.18	1.41
Asp 50 (mg L^{-1})	71.22	6.40	5.40	1.55
Asp 75 (mg L^{-1})	76.20	7.66	5.88	1.75
Asp 100 (mg L^{-1})	72.30	6.30	5.63	1.68
LSD at 5%	2.11	0.59	0.17	0.07

ASP: Aspartic acid, LSD: Least significant difference

Table 2: Effect of aspartic acid treatments on photosynthetic pigments of two wheat cultivars

	Fresh leaf tissues (μg g^{-1})				
Treatments	Chlorophyll a	Chlorophyll b	Carotenoids	Chlor+Chlor b	Total pigments
Benisuif 4 cv.					
Control	14.3616	6.0234	3.0254	20.3850	23.4104
Asp 50 (mg L^{-1})	16.6275	7.5768	3.675	24.2043	27.8793
Asp 75 (mg L^{-1})	22.1505	8.9960	4.952	31.1465	36.0985
Asp100 (mg L^{-1})	20.0243	7.5735	4.125	27.5978	31.7228
Sohag 3 cv.					
Control	13.542	5.350	2.578	18.892	21.470
Asp 50 (mg L^{-1})	14.850	5.750	2.958	20.600	23.558
Asp 75 (mg L^{-1})	20.035	6.165	3.524	26.200	29.724
Asp100 (mg L^{-1})	16.612	5.745	3.247	22.357	25.604
LSD at 5%	0.080	0.013	0.045	0.089	0.099

ASP: Aspartic acid, LSD: Least significant difference , Chlor: Chlorophyll

Table 3: Effect of aspartic acid treatments on grain yield and yield components of two wheat cultivars

Treatments	Spike length (cm)	No. of spikelets/spike	Straw yield (t/fed)	Biological yield (t/fed)	Grains weight (Ardabe/fed)
Benisuif 4 cv.					
Control	7.2	17.5	3.06	4.82	12.21
Asp 50 (mg L^{-1})	8.8	20.0	3.48	5.54	13.76
Asp 75 (mg L^{-1})	9.6	20.5	3.67	6.15	16.60
Asp 100 (mg L^{-1})	8.8	18.5	3.42	5.92	14.98
Sohag 3 cv.					
Control	7.5	18.0	2.95	4.73	11.88
Asp 50 (mg L^{-1})	8.2	19.5	2.96	5.27	13.62
Asp 75 (mg L^{-1})	9.0	20.0	3.58	6.00	16.14
Asp100 (mg L^{-1})	8.6	18.5	3.28	5.46	14.44
LSD at 5%	0.92	1.48	0.13	0.30	0.45

ASP: Aspartic acid, LSD: Least significant difference

Table 4: Effect of aspartic acid treatments on content of carbohydrate, protein and macro-elements of two wheat cultivars

Treatments	Carbohydrate content (%)	Protein (%)	N (%)	P (%)	K (%)
Benisuif 4 cv.					
Control	46.21	14.51	2.32	1.68	2.88
Asp 50 (mg L^{-1})	47.03	15.71	2.51	1.82	2.88
Asp 75 (mg L^{-1})	48.23	16.35	2.61	1.90	3.34
Asp 100 (mg L^{-1})	47.59	15.86	2.53	1.87	3.22
Sohag 3 cv.					
Control	44.82	15.50	2.48	1.76	2.77
Asp 50 (mg L^{-1})	45.23	16.68	2.66	1.81	2.93
Asp 75 (mg L^{-1})	47.31	16.92	2.70	1.89	3.17
Asp 100 (mg L^{-1})	47.03	16.64	2.66	1.91	3.00
LSD at 5%	0.28	0.07	0.01	0.01	0.08

ASP: Aspartic acid, LSD: Least significant difference, P: Phosphorus, K: Potassium

grains than Sohag 3 cv. when grown under sandy soil conditions (Table 4). Meanwhile, Sohag 3 cv. had the higher content of protein and phosphorous. Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused significant increased in carbohydrate, protein N, P, K contents under investigation in both wheat cultivars as compared with corresponding controls. Aspartic acid at 75 mg L^{-1} was the most pronounced treatment in both wheat cultivars.

Data in Table 4 indicated that increases in carbohydrates content as affected by different concentrations of aspartic acid treatments followed the same trend obtained on vegetative growth (Table 1) and photosynthetic pigments (Table 2).

DISCUSSION

The obtained results showed that Benisuif 4 cv. was characterized by higher significant growth parameters, photosynthetic pigments, grains, straw and biological yield than Sohag 3 cv. when grown under sandy soil conditions. Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused marked significant increases in growth parameters, photosynthetic pigments, yield and yield components, quality of the yielded grains (carbohydrate, protein, N, P, K contents) in both wheat cultivars. Benisuif 4 cv. was characterized by higher significant growth parameters than Sohag 3 cv. when grown under sandy soil conditions. Worthy, there were significant differences in all growth characters of wheat cultivars (Sakha93, Gemiza7 and Gemiza9)[18]. Aspartic acid treatments (50, 75 and 100 mg L^{-1}) caused significant increase in all growth parameters under investigation in both wheat cultivars. Previous works have demonstrated that aspartic acid application can influence the physiological activities in plant growth and their yield[19]. Amino acids promoted development of the root system and activate growth of the above-ground plant part[20]. Amino acids may be play main role in metabolism and protein assimilation of plant which necessary for plant cells and consequently increase fresh and dry weight of plant[21]. Further, amino acids can play different roles in plants, they can act as stress-reducing agents, source of nitrogen and hormone precursors[22-24], thereby inducing growth parameters. Moreover, 75 mg L^{-1} aspartic acid was the most pronounced treatment in increasing all components of photosynthetic pigments of both cultivars. Glutamine or asparagine treatments resulted in increasing soybean fresh weight and retention of green color[25]. Amino acid has a chelating impact on micronutrients as Mg, which makes the absorption and transportation of nutrients inside the plant easier due to its impact on cell membrane permeability[26]. The enhancement effect of aspartic acid application on photosynthetic pigments was in a good harmony with those obtained using asparagine and glutamine on French bean plant[27], using amino acid mixture on faba bean plant[28] and using aspartic acid on berseem plant[29] and in a good supports to the growth rate.

Benisuif 4 cv. was characterized by higher yield components than Sohag 3 cv. as shown in Table 3. Since, wheat cultivars differed in their yield and yield components as shown earlier by Sultan *et al.*[30] as well as their grain concentrations[31] of N, Zn and Fe. Wheat cultivars were significantly different in plant height, spike length, number of spikes, number of grains per spike and grain weight per spike[32]. In addition grain, straw and biological yields and its components were significantly differed owing to cultivar differences[33].

Aspartic acid treatments had significant enhancement effect on yield and yield components in both cultivars. Grain yield of wheat is affected by many factors of which cultivar, nitrogen fertilizer and amino acids application played an important role in determining productivity of wheat. Since, foliar application of amino acids caused the highest significant increases in plant height, number of tillers/m^2, number of grains/spike, 1000-grains weight and grain yield[34]. Likewise, foliar spraying of amino acids induced significant increases in plant height, no. of leaves/plant, no. of tillers/plant, flag leaf area, no. of spikes/m^2, no. of grains/spike, 1000-grain weight, grain yield (t/fed), straw yield (t/fed), protein and carbohydrate percentage in grain[35].

Aspartic acid treatments caused significant increases in carbohydrate, protein N, P, K contents under investigation in both wheat cultivars. The increases in carbohydrates content as affected by different concentrations of aspartic acid treatments followed the same trend obtained on vegetative growth and photosynthetic pigments. The promotive effect of the amino acids (aspartic acid) on carbohydrates constituents may be due to their role in biosynthesis of chlorophyll molecules which in turn affected total carbohydrates contents. Glutamic acid application increased carbohydrates of wheat plant in different plant organs[36]. Likewise, the enhancement effect of aspartic acid on the protein content of the yielded grains may be attributed to the role of amino acids are organic nitrogenous compounds and building blocks in the synthesis of proteins and enzymes[3] and known as growth factors of higher plants[4]. Asparagine and glutamine are major amino acids transported from leaf canopy to developing seeds and then converted into all other amino acids including lysine and threonine and the free amino acids are subsequently incorporated into seed proteins[37]. Glutamic acid application increased carbohydrates and total protein[27]. Moreover, aspartic acid treatment increased protein contents of berseem plant[29].

Moreover, amino acids had stimulating effect on elements because of amino acid has a chelating impact on micro-nutrients, which make the absorption and transportation of these nutrients inside plant easier due to its impact on cell membrane permeability[26]. Amino acids treatments may reduce application of fertilizers and improve the quality of some plants via increasing plant mineral uptake and improving the nutrients use efficiency[5]. Accordingly, amino acids promote development of the root system and activate growth of the aboveground plant part[20]. The author claimed that the intensity of mineral nutrition elements intake through the roots depends on the amount of aspartic and glutamic acid in plants.

CONCLUSION

It could be concluded that aspartic acid treatments (50, 75 and 100 mg L^{-1}) can be effective for increasing quality and quantity of two wheat cultivars grown under sandy soil conditions, specially 75 mg L^{-1} was the most pronounced treatment.

SIGNIFICANCE STATEMENT

This study discovered that aspartic acid and glutamic acid have strong effect on the wheat cultivar's quality and quantity that can be beneficial for the well production of wheat cultivars. This study will help the researchers to uncover the critical areas to improve the quality of wheat cultivars that many researchers were not able to explore.

REFERENCES

1. Johansson, E., M.L. Prieto-Linde, G. Svensson and J.O. Jonsson, 2003. Influences of cultivar, cultivation year and fertilizer rate on amount of protein groups and amount and size distribution of mono- and polymeric proteins in wheat. J. Agric. Sci., 140: 275-284.
2. Svec, I., M. Hruskova and O. Jirsa, 2006. Evaluation of winter wheat varieties from three harvest years. Getreidetechnologie, 60: 78-86.
3. Davies, D.D., 1982. Physiological Aspects of Protein Turnover. In: Nucleic Acids and Proteins in Plants I: Structure, Biochemistry and Physiology of Proteins, Boulter, D. and B. Parthier (Eds.). Springer, Berlin, Germany, ISBN: 978-3-642-68237-7, pp: 189-228.
4. Levitt, J., 1980. Responses of Plants to Environmental Stresses, Volume 1: Chilling, Freezing and High Temperature Stresses. 2nd Edn., Academic Press, New York, USA., ISBN-13: 9780124455016, pp: 309-317.
5. Vernieri, P., E. Borghesi, A. Ferrante and G. Magnani, 2005. Application of biostimulants in floating system for improving rocket quality. J. Food Agric. Environ., 3: 86-88.
6. Alaru, M., U. Laur and E. Jaama, 2003. Influence of nitrogen and weather conditions on the grain quality of winter triticale. Agron. Res., 1: 3-10.

7. Meijer, A.J., 2003. Amino acids as regulators and components of nonproteinogenic pathways. J. Nutr., 133: 2057S-2062S.
8. Akladious, S.A. and S.M. Abbas, 2013. Alleviation of seawater stress on tomato by foliar application of aspartic acid and glutathione. J. Stress Physiol. Biochem., 9: 282-298.
9. Galili, S., R. Amir and G. Galili, 2008. Genetic engineering of amino acid metabolism in plants. Adv. Plant Biochem. Mol. Biol., 1: 49-80.
10. Rashad, E.S.M., H.M. El-Abagg and A.A. Amin, 2003. Physiological effects of some bioregulators on growth and productivity of two broad bean cultivars. Egypt. J. Applied Sci., 18: 132-149.
11. Ahmed, A.H.H., M.R. Nesiem, A.M. Hewedy and H. Sallam, 2010. Effect of some simulative compounds on growth, yield and chemical composition of snap bean plants grown under calcareous soil conditions. J. Am. Sci., 6: 552-569.
12. Buchanan, B.B., W. Gruissem and R.L. Jones, 2000. Biochemistry and Molecular Biology of Plants. 2nd Edn., Willy-Blackwell, Rockville, MD., USA., ISBN-13: 978-0470714218, Pages: 1280.
13. Taiz, L. and E. Zeiger, 2010. Plant Physiology. 5th Edn., Sinauer Associates, Sunderland, MA., USA., ISBN-13: 9780878938667, Pages: 782.
14. Moran, R., 1982. Formulae for determination of chlorophyllous pigments extracted with *N,N*-dimethylformamide. Plant Physiol., 69: 1376-1381.
15. Herbert, D., P.J. Phipps and R.E. Strange, 1971. Chemical analysis of microbial cells. Methods Microbiol., 5: 209-344.
16. Chapman, H.D. and P.F. Pratt, 1978. Methods of analysis for soils, plants and water. University of California, Division of Agricultural Sciences Publication 4034, September 1978, USA., pp: 162-165.
17. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., Iowa State University Press, Iowa, USA., ISBN-10: 0813815606, Pages: 507.
18. Zaki, N.M., M.S. Hassanein and K.M. Gamal El-Din, 2007. Growth and yield of some wheat cultivars irrigated with saline water in newly cultivated land as affected by biofertilization. J. Applied Sci. Res., 3: 1121-1126.
19. Rizwan, M., S. Ali, M.Z. Akbar, M.B. Shakoor, A. Mahmood, W. Ishaque and A. Hussain, 2017. Foliar application of aspartic acid lowers cadmium uptake and Cd-induced oxidative stress in rice under Cd stress. Environ. Sci. Pollut. Res., 24: 21938-21947.
20. Nikiforova, V.J., M. Bielecka, B. Gakiere, S. Krueger and J. Rinder *et al*., 2006. Effect of sulfur availability on the integrity of amino acid biosynthesis in plants. Amino Acids, 30: 173-183.
21. Abo Sedera, F.A., A.L. Amany, A.A. Abd El-Latif, L.A.A. Bader and S.M. Rezk, 2010. Effect of NPK mineral fertilizer levels and foliar application with humic and amino acids on yield and quality of strawberry. Egypt. J. Applied Sci., 25: 154-169.
22. Zhao, Y., 2010. Auxin biosynthesis and its role in plant development. Annu. Rev. Plant Biol., 61: 49-64.
23. DeLille, J.M., P.C. Sehnke and R.J. Ferl, 2001. The Arabidopsis 14-3-3 family of signaling regulators. Plant Physiol., 126: 35-38.
24. Maeda, H. and N. Dudareva, 2012. The shikimate pathway and aromatic amino acid biosynthesis in plants. Annu. Rev. Plant Biol., 63: 73-105.
25. Wettlaufer, S.H. and R.L. Obendorf, 1991. Ureides and amides as nitrogen sources for soybean seed growth and maturation *in vitro*. Crop Sci., 31: 1319-1323.
26. Marschner, H., 1995. Mineral Nutrition of Higher Plants. 2nd Edn., Academic Press Ltd., London, New York, ISBN-13: 978-0124735439, Pages: 889.
27. Haroun, S.A., W.M. Shukry and O. El-Sawy, 2010. Effect of asparagine or glutamine on growth and metabolic changes in *Phaseolus vulgaris* under *in vitro* conditions. Biosci. Res., 7: 1-21.
28. Sadak, M.S.H., M.T. Abdelhamid and U. Schmidhalter, 2015. Effect of foliar application of aminoacids on plant yield and some physiological parameters in bean plants irrigated with seawater. Acta Biologica Colombiana, 20: 141-152.
29. Zakirullah, M., S. Innayat, T. Jan, M. Arif, M. Ali and M. Alam, 2018. The effect of different levels of amino acid and zinc on the quality and quantity of Berseem (*Trifolium alexandrinum*). Asian J. Agric. Biol., 6: 379-384.
30. Sultan, M.S., A.N. Attia, A.M. Salma, S.A. El-Moursy, E.M. Said and M.M. Abou El-Nagah, 2000. Response of some wheat cultivars to planting and harvesting dates under different seed rates. Proceedings of the 9th Conference on Agronomy, September 2-3, 2000, Minufiya University, Egypt.
31. Cakmak, I., H. Ozkan, H.J. Braun, R.M. Welch and V. Romheld, 2000. Zinc and iron concentrations in seeds of wild, primitive and modern wheats. Food Nutr. Bull., 21: 401-403.
32. Sharaan, A.N., F.S. Abd El-Samie and I.A. Abd El-Gawad, 2000. Response of wheat varieties (*Triticum aestivum* L.) to some environmental influence: Effect of planting date and drought at different plant stages on yield and its components. Proceedings of the 9th Conference on Agronomy, September 2-3, 2000, Minufiya University, Egypt, pp: 1-5.

33. Zaki, N.M., M.A. Ahmed and M.S. Hassanein, 2004. Growth and yield of some wheat cultivars irrigated with saline water in newly cultivated land as affected by nitrogen fertilization. Ann. Agric. Sci. Moshtohor, 42: 515-525.
34. Azimi, M.S., J. Daneshian, S. Sayfzadeh and S. Zare, 2013. Evaluation of amino acid and salicylic acid application on yield and growth of wheat under water deficit. Int. J. Agric. Crop Sic., 5-8: 816-819.
35. Hammad, S.A.R. and O.A.M. Ali, 2014. Physiological and biochemical studies on drought tolerance of wheat plants by application of amino acids and yeast extract. Ann. Agric. Sci., 59: 133-145.
36. Mazher, A.A.M., S.M. Zaghloul, S.A. Mahmoud and H.S. Siam, 2011. Stimulatory effect of kinetin, ascorbic acid and glutamic acid on growth and chemical constituents of *Codiaeum variegatum* L. Plant. Am.-Eurasian J. Agric. Environ. Sci., 10: 318-323.
37. Galili, G. and B.A. Larkins, 1998. Enhancing the Content of the Essential Amnio Acids Lysine and Thereonine in Plants. In: Plant Amino Acids: Biochemistry and Biotechnology, Singh, B.K. (Ed.). CRC Press, Boca Raton, FL., USA., ISBN-13: 9780824702045, pp: 487-507.