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Original Article

Amino acids foliar application for maximizing growth, productivity and quality of peanut grown under sandy soil

Aplicação foliar de aminoácidos para maximizar o crescimento, produtividade e qualidade do amendoim cultivado em solo arenoso

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Abstract

Two field experiments were conducted during 2019 and 2020 summer seasons at the experimental station of national research center, Al-Nubaryia district, El-Behaira Governorate, Egypt, to study the effect of Phenyl alanine and Aspartic acid foliar fertilizers at rates of (0.0, 50, 75 and 100 ppm) on morphological characters, photosynthetic pigments, seed yield and its components as well as seed quality of groundnut grown under sandy soil. Results indicated superiority of aspartic acid over phenyl alanine on increasing different growth parameters, chlorophyll b, biological and seed yields/plant, biological, seed and oil yields (kg/fed.), % of carbohydrate in peanut seeds. Meanwhile, phenyl alanine was superior on increasing carotenoids, indole acetic acid, phenolics, free amino acids, flavonoids, Lycopene, β-Carotene contents, antioxidant activity expressed as (1,1-diphenyl-2-picrylhydrazyl DPPH %) and shilling percentage. In addition, aspartic acid and phenyl alanine with various levels caused significant increases in growth and seed yield quantity and quality of peanut plants through increases in photosynthetic pigments, indole acetic acid, phenolics and free amino acids contents. Aspartic acid was more effective than phenyl alanine, Foliar treatment with 100 mg/L aspartic acid increased oil yield (700.36 over 568.05 ton/fed.) and seed yield (1531.98 over 1253.49 kg/fed.). Finally, it can conclude that using aspartic acid and phenyl alanine as foliar treatment improved growth and yield of ground nut plants under sandy soil.

Keywords: peanut, amino acids, phenyl alanine and aspartic acid, productivity, quality, sandy soil.

Resumo

Dois experimentos de campo foram conduzidos durante as temporadas de verão de 2019 e 2020 na estação experimental do centro nacional de pesquisa, distrito de Al-Nubaryia, província de El-Behaira, Egito, para estudar o efeito de fenilalanina e fertilizantes foliares de ácido aspártico a taxas de (0,0, 50, 75 e 100ppm) em caracteres morfológicos, pigmentos fotossintéticos, rendimento de sementes e seus componentes, bem como qualidade de sementes de amendoim cultivadas em solo arenoso. Os resultados indicaram superioridade do ácido aspártico sobre a fenilalanina no aumento de diferentes parâmetros de crescimento, clorofila b, rendimento biológico e de sementes/planta, biológico, de sementes e óleo (Kg/alimentado), porcentagem de carboidratos em sementes de amendoim. Enquanto isso, a fenilalanina foi superior no aumento de carotonóides, ácido indolacético, fenólicos, aminoácidos livres, flavonóides, licopeno, teores de B-caroteno, atividade antioxidante expressa como (1,1-difenil-2-picrilhidrazil DPPH%) e porcentagem de shilling. Além disso, ácido aspártico e fenilalanina com vários níveis causaram aumentos significativos no crescimento e produção de sementes, quantidade e qualidade de plantas de amendoim através de aumentos nos teores de pigmentos fotossintéticos, ácido indolacético, fenólicos e aminoácidos livres. O ácido aspártico foi mais eficaz que a fenilalanina. O tratamento foliar com 100 mg/L de ácido aspártico aumentou o rendimento de óleo (700,36 sobre 568,05 ton./alimentado) e o rendimento de sementes (1531,98 sobre 1253,49 kg/alimentação). Finalmente, pôde-se concluir que o uso de ácido aspártico e fenilalanina como tratamento foliar melhorou o crescimento e a produção de plantas de amendoim em solo arenoso.

Palavras-chave: amendoim, aminoácidos, fenilalanina e ácido aspártico, produtividade, qualidade, solo arenoso.

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1. Introduction

Peanut or "groundnuts" plants, as known in many parts of the world, are edible legume seeds. Peanut (*Arachis hypogaea* L.) is renowned as the king of oil seed crops as it is among the most important summer oil seed and protein crops (Arya et al., 2016). Peanut plants are the 13th food crop, 4th oil seed crop and the 3rd source of vegetable protein (Taru et al., 2008). The economic value primarily comes from its short soil lifecycle, which provides higher economic output compared with other crops. Peanuts are as popular as they are nutritious. In addition, it is an amazing plant-based source of oil, protein, vitamins, minerals, and plant components. The nutritive value of peanut seeds is very high as it contains 40-50 percent of oil, 25-30 percent protein, 20 percent carbohydrates and 5 percent ash, some minerals as magnesium and calcium depending on the variety and agricultural treatments (Li et al., 2014; Jani and Devani, 2020; Bakry et al., 2020). Moreover, peanut leaves were used as animal feed (Atasie et al., 2009; Suchoszek-Lukaniuk et al., 2011). Thus, significant attention was paid to this crop from both the government as well as researchers, mainly because of its suitability to grow in the newly reclaimed sandy soil. Beside oil, peanuts are commonly used for manufacture of peanut butter, confectionery, roasted peanuts and snack foods, meat product extenders, soups, and desserts (Bonku and Yu, 2020).

Amino acids are among possible technique for increasing crop productivity. They are organic nitrogen polymers that are used as building blocks of proteins and enzymes (Shokunbi et al., 2012) and are known as stronger plant growth bio-regulators (Pessarakli et al., 2015). Furthermore, the significance of amino acids arises from their widespread use in the biosynthesis non-proteinic nitrogenous products such as pigments, vitamins, coenzymes, purine, and pyrimidine bases (Buchanan et al., 2000). Glutamate, glutamine, and aspartate are the major amino acids produced by plant cells and other amino acids can be composed from them (Buchanan et al., 2000; Taiz and Zeiger, 2013).

Amino acids have different functions on plants; including acting as stress-relievers, nitrogen sources and hormone precursors (Zhao, 2010; DeLille et al., 2001; Maeda and Dudareva, 2012). Amino acids might exist in various forms in different soil types; however, their half-life is limited, and their plant uptake is only possible due to the presence of transporters inside root cells (Jamtgard et al., 2010). Various research demonstrated the usefulness of amino acid absorption by plant cells (Gioseffi et al., 2012). In this context, exogenous treatment of amino acids through seed soaking or foliar treatment improved plant growth and production, because molecules can serve as signals of numerous valuable biochemical processes of plants (Abdel-Mawgoud et al., 2011; Koukounaras et al., 2013; Sadak et al., 2014; El-Awadi et al., 2019).

External use of various amino acids as bioregulators can reduce fertilizer consumption and enhance productivity of different crops through improving plant minerals uptake and improve nutrients use efficiency (Vernieri et al., 2005). Amino acids facilitate formation of root system and improve growth of the aboveground plant parts (Nikiforova et al., 2006). According to much research, the amount of mineral nutrients absorbed through root parts is dependent on how many aspartic and glutamic acids are present in plants (Persson et al., 2006).

Previous studies showed that, when amino acids are utilized as plant fertilizer, they improve respiration, photosynthesis, and water cycle activities. Additionally, these amino acids raised ascorbic acid levels, accelerated protein biosynthesis, and improved plant growth and productivity (Meijer, 2003). Moreover, amino acids have a chelating influence on micronutrients that promote the uptake and transport of these nutrients within plant through their effect on cell membrane permeability (Marschner, 2011). Cultivation of peanut plant in sandy soil suffers from decreased seed productivity. These decreases might be due to different adverse environmental conditions as decreased water availability, nutrient deprivation and temperature fluctuations in sandy soil. Thus, amino acids have an important effect in plants under these conditions (Zhao, 2010; DeLille et al., 2001; Maeda and Dudareva, 2012).

So, the goal of this investigation was to use two amino acids phenyl alanine and aspartic acid with different concentrations for improving growth, productivity and seed quality of peanut plants grown under sandy soil conditions.

2. Materials and Methods

2.1. Experimental procedure

Two field experiments were conducted during 2019 and 2020 summer seasons at the experimental farm of National Research Center, (latitude 30o 30' 1.4' 'N, longitude 30o19' 10.9" E, and 21 m+MSL (mean sea level) at (NRC), Al Nubaryia district, El-Behaira Governorate, Egypt.

The experimental soil (0-30 depth) was analyzed according to the method described by Carter and Gregorich (2006). Soil texture was sandy and having the following characteristics: sand 94.7%, pH 8.6, Organic matter 0.8%, $CaCO_3$ 2.4%, EC 0.13 mmhos/cm^3, available N 18.0 ppm, available P 18.0 ppm, available K 104 ppm and available Zn 0.05 ppm.

The experimental design was split plot design in three replications, where the amino acids, Phenyl alanine and Aspartic acid were located in main plots and their concentrations were used as foliar applications at rates of (0.0, 50, 75 and 100 ppm) were randomly applied in sub plots and carried out twice, the first application after 30 days from sowing date and the second application was done after two weeks from the first one; i.e., 45 days from sowing date. The plot area was 10.5 m^2 consisting of five rows (3.5 m length and 60 cm between rows), which one fed. = 4200 m^2.

Peanut (*Arachis hypogaea* L.) variety Gize-6 were procured from Oil Crops Research Section, Field Crops Research Institute, Agricultural Research Center – Giza – Egypt, was inoculated just before sowing with the specific *Rhizobium* bacteria inoculants. Seeds of peanut plants were sown in the first week of May in both seasons.

Phosphorus fertilizer as Calcium superphosphate (15.5% P_2O_5) was added during the seed bed preparation at rate of 60 kg P_2O_5 /fed. Potassium Sulphate (48%K_2O) at the rate of 50 kg/fed. was applied at sowing. Nitrogen fertilizer was added at a rate of 30 kg N/fed. as ammonium sulfate (20.6% N) in two equal portions, the first half at sowing and the second after 30 days later.

The normal cultural practices for groundnut were applied as recommended in the district. Sprinkler irrigation was applied as plants needed.

2.2. Recording of data

The data pertaining to morphology of vegetative growth, photosynthetic pigments, seed yield components and seed oil percentage of peanut cv. Giza-6 as affected by foliar application with different levels of Phenyl alanine and Aspartic acid to the following items.

2.2.1. Morphological characters of vegetative growth

Shoot length (cm), No. of branches/ plant, shoot fresh weight (g), shoot dry weight (g), Root length (cm), root fresh weight (g) and root dry weight (g).

2.2.2. Yield and yield components characters

A random sample of five plants was assigned for investigation in each plot. The plants were taken from the middle region of the plot at harvest time (120 days from sowing date), data on seed yield characters were recorded follows:

plant height (cm), number of branches/plant, number of pods/plant, number of seeds/pod, biological yield/plant (g), straw yield/Plant (g), Pod yield/Plant (g), Seed yield/ plant (g) and shilling %.

The whole plot was harvested, and the pods were air dried to calculate seed yield per feddan. Oil yield was calculated per feddan.

2.2.3. Chemical analysis

- In peanut shoots

Photosynthetic pigments: Total chlorophyll a, b and carotenoids contents in fresh leaves of lupines plant were estimated using the method of Lichtenthaler and Buschmann (2001). The fresh tissue was ground in a mortar and pestles using 80% acetone. The optical density (OD) of the solution was recorded at 662 and 645 nm (for chlorophyll a and b, respectively) and 470 nm (for carotenoids) using a spectrophotometer (Shimadzu UV-1700, Tokyo, Japan). The values of photosynthetic pigments were expressed in mg/g FW.

Indole acetic acid content: A known weight of the fresh samples was taken and extracted with 85% cold methanol (v/v) for three times at 0 °C. The combined extracts were collected and made up to a known volume with cold methanol. Then take 1 mL of the methanolic extract and 4 mL of PDAB reagent (para-dimethylamino benzoic acid 1g dissolve in 50 mL HCl, 50 mL of ethanol 95%) and left for 60 min in 30-400C. The developing color was spectrophotometrically measured at wave length of 530 nm. As described by Gusmiaty et al. (2019).

Total phenol content: The extract was extracted as IAA extraction, and then 0.5 mL of the extraction was added to 0.5 mL Folin, shaked and allowed to stand for 3 min. Then one mL of saturated sodium carbonate was added to each tube followed by distilled water shaken and allowed to stand for 60min. The optical density was determined at wave length of 725 nm using spectrophotometer as described by Gonzalez et al. (2003).

Free amino acids: Free amino acid and proline contents were extracted according to the method described by Kalsoom et al. (2016). Free amino acid was determined with the ninhydrin reagent method described by Tamayo and Bonjoch (2001). Further, 1.0 mL acetate buffer (pH 5.4) and 1.0 mL chromogenic agent were added to 1.0 mL free amino acid extraction. The mixture was heated in boiling water bath for 15 min. After cooled in tap water, 3 mL ethanol (60% v/v) was added. The absorbance at 570 nm was then monitored using Spekol-spectrophotometerVEB Carl Zeiss.

2.2.4. In peanut seeds

Oil contents: The oil of peanut seeds was extracted according to Das et al. (2002) the powdered seeds were shaken overnight with isopropanol: chloroform (1:1). The solvent was evaporated under reduced pressure of CO_2 atmosphere. The lipid residue is taken up in a chloroform: methanol (2:1 v/v) and given a Folch wash, the dissolved total oils were purified by washing with 1% aqueous saline solution. The aqueous phases were washed with chloroform that was combined with the pure oil solution. Chloroform was evaporated and the total pure oil was weighed.

Fatty acid analysis: Analysis of fatty acids was determined from seed oil specimens of the second season according (Vogel, 1975). GLC was carried out under the same conditions mentioned (Fedak and De La Roche, 1977).

Total carbohydrate: Determination of total carbohydrates was carried out according to Albalasmeh et al. (2013). A known mass (0.2-0.5 g) of dried tissue was placed in a test tube, and then 10 mL of sulphuric acid (1N) was added. The tube was sealed and placed overnight in an oven at 100 °C. The solution was then filtered into a measuring flask (100 mL) and completed to the mark with distilled water. The total sugars were determined Colorimeterically according to Littell et al. (2006) as follows: An aliquot of 1 mL of sugar solution was transferred into test tube and treated with 1ml of 5% aqueous phenol solution followed by 5.0 mL of concentrated sulphuric acid. The tubes were thoroughly shaken for ten minutes then placed in a water bath at 23-30 °C for 20 minutes. The optical density of the developed color was measured at 490 nm using Shimadzu spectrophotometer model UV 1201.

Flavonoids contents: Flavonoid content of crude extract was deter-mined by the aluminum chloride colorimetric method (Ordoñez et al., 2006), In brief, 50 µL of crude extract (1 mg/mL ethanol) were made up to 1 mL with methanol, mixed with 4 mL of distilled water and then 0.3 mL of 5% $NaNO_2$ solution; 0.3 mL of 10% $AlCl_3$ solution was added after 5 min of incubation, and the mixture was allowed to stand for 6 min. Then, 2 mL of 1 mol/L NaOH solution were added, and the

final volume of the mixture was brought to 10 mL with double-distilled water. The mixture was allowed to stand for 15 min, and absorbance was measured at 510 nm. The total flavonoid content was calculated from a calibration curve, and the result was expressed as mg rutin equivalent per g dry weight.

Lycopene and β-carotene analysis: The method used for determination of lycopene and β-carotene as described by Nagata and Yamashita (1992). One gram of ground wheat grains was put in a test tube. Then, 10 mL of the mixed solvents of acetone and hexane in the ratio 4:6 (volume per volume) were added and mixed well using a spatula. Two other concentrations of extracted matter were made in the same way by adding 14 mL and 18 mL, respectively, of mixed solvent to 1 g of minced arils. The dilutions were selected to be just below the capability of the absorption range of the UV-Visible spectrophotometer (Thermo-Spintronic, GENESYS 10 UV-Vis; USA). Before performing the measurement. The extracts were homogenized using a homogenizer (Polytron®, PT-MR 2100; Switzerland) at 15,000 rpm for 1 min. Then, the light absorption values (A) at 453, 505, 663 and 645 nm wavelength were recorded for the determination of the lycopene and β-carotene contents in each sample. Equations 1 and 2 were used to calculate the lycopene and β-Carotene contents in milligrams per 100 mL of mixed solvent.

The obtained values then were calculated further to be based on 100 g of grain (DW).

$$Lycopene)\ mg/100\ mL) = 0.0458A_{663} + 0.204A_{645} + 0.372A_{505} - 0:0806A_{453} \quad (1)$$

$$\beta - carotene\ (mg/100\ mL) = 0.216_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453} \quad (2)$$

Free radical scavenging activity (DPPH%): The free radical scavenging activity by different plant extracts was done according to the method (Nagata and Yamashita, 1992). 50 µL of the plant extract in methanol, yielding 100 µg/mL respectively in each reaction was mixed with 1 mL of 0.1 mM DPPH in methanol solution and 450 µL of 50 mM Tris-HCl buffer (p) H 7.4). Methanol (50 µl) only was used as control of experiment. After 30 min of incubation at room temperature the reduction of the DPPH free radical was measured reading the absorbance at 517 nm. L-Ascorbic acid and BHT used as controls. The percent inhibition was calculated from the following Equation 3:

$$\%\ Inhibition = \left[\frac{Absorbance\ of\ control - Absorbance\ of\ test\ sample}{Absorbance\ of\ control}\right] \times 100 \quad (3)$$

2.3. Statistical analysis

Combined analysis of variance of split plot design for the substances and their concentrations across the two seasons were performed using SAS® (Wintola and Afolayan, 2011). Least significant differences (LSD) were calculated according (Freund et al., 2010).

3. Results

3.1. Effect of phenyl alanine or aspartic acid on growth indices, biochemical aspects, seed yield and its components of peanut plants

3.1.1. Changes on growth parameters

Table 1 showed the changes in growth indices of peanut plants foliar treated with either phenyl alanine or aspartic acid. Data show the superiority of aspartic acid foliar treatments and significantly increasing on growth indices (shoot and root length, fresh and dry wt.) over phenyl alanine treatments. Meanwhile, phenyl alanine treatments were superior on increasing number of branches/ plants significantly over aspartic acid treatment.

3.1.2. Changes in photosynthetic pigments, IAA, phenolics and free amino acids contents

The changes in photosynthetic pigments presented, indole acetic acid (IAA), phenolic and free amino acids contents of peanut plant treated with either phenyl alanine or aspartic acid are presented in Figure 1. Foliar treatments of phenyl alanine increased carotenoids and total pigments compared with aspartic acid treated plants. Meanwhile, aspartic acid treatments increased markedly chlorophyll b as compared with phenyl alanine treated plants and

Table 1. Effect of phenyl alanine or aspartic acid on growth, seed yield and its components of peanut plants grown under sandy soil (data are means of two seasons).

Characters	Treatments		LSD @ 0.05
	Phenyl alanine	Aspartic acid	
Shoot length (cm)	18.17	19.67	3.11
No. of branches/ plant	5.17	4.00	0.95
Shoot fresh weight (g)	71.47	96.31	50.51
Shoot dry weight (g)	34.32	37.14	19.51
Root length (cm)	10.00	11.17	1.79
Root fresh weight (g)	2.03	2.34	0.44
Root dry weight (g)	1.04	1.22	0.53
Plant height (cm)	22.42	24.33	n. s
No. of branches/ plant	4.00	4.67	n. s
No. of pods/plant	23.75	31.83	n. s
No seeds/pod	2.25	2.33	n. s
Biological yield/plant (g)	72.22	87.67	2.18
Pod yield/ plant (g)	30.61	38.46	2.91
Seed yield/plant (g)	18.78	25.62	1.38
Shilling %	37.97	33.09	2.32
Oil yield (kg/fed.)	419.70	530.88	25.57
Biological yield (ton/fed.)	2.72	2.77	0.04
Seed yield (Kg/fed.)	938.35	1183.25	56.46

n.s: non significant.

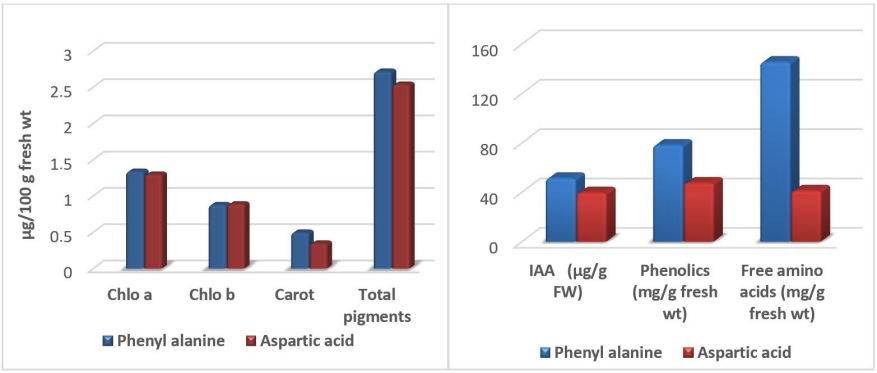

Figure 1. Effect of phenyl alanine or aspartic acid on photosynthetic pigments (µg/100 g fresh weight), IAA (µg/g FW), phenolic and free amino acids (mg/g FW) of peanut plant grown under sandy soil. $LSD_{0.05}$: Chlorophyll a: n.s., Chlorophyll b: 0.01, Carotenoids: 0.01, Total Pigments: 0.06. IAA: 0.254, Phenolic 0.11 and free amino acids: 0.66.

nonsignificant effect between phenyl alanine and aspartic acid foliar treatments on chlorophyll a content of peanut plants under sandy soil (Figure 1).

Data presented in Figure 1 also showed that phenylalanine foliar treatment significantly increased IAA, phenolics and free amino acids contents of peanut plants as compared with aspartic acid treated peanut plants grown under sandy soil.

3.1.3. Changes in yield and yield components

The effect of phenyl alanine or aspartic acid foliar treatment on seed yield and its components of peanut plants under sandy soil are presented in Table 1. Data clearly showed that foliar treatment of peanut plants with aspartic acid caused marked increases in plant height, number of branches and pods/plant, number of seeds /pods, seeds yield/plant and biological yield (ton/fed). Meanwhile, caused significant increases in biological yield/plant, shoot and pods weight, seeds weight/plant, oil yield (kg/fed) and seed yield (kg/fed) as compared with phenyl alanine treated plants. Meanwhile, phenyl alanine treatment increased significantly shilling % as compared with pyridoxine treated plants.

3.1.4. Changes in nutritional values in seeds of peanut

Figure 2 showed the effect of phenyl alanine or aspartic acid foliar treatments on nutritional value of the seed yield of peanut. Data clearly showed that foliar treatment of phenyl alanine treatment markedly increased oil% and significantly, flavonoids, lycopene, and antioxidant activities (DPPH) of seed yield seeds as compared with aspartic acid treated plants. Meanwhile, carbohydrates contents showed significant increase in response to aspartic acid treatment compared with the other treatment.

3.2. Effect of concentrations on growth indices, biochemical aspects, seed yield and its components of peanut plants

3.2.1. Changes on growth parameters

The effect of different concentrations of either phenyl alanine or aspartic acid treatment on growth indices of peanut plants are in Table 2. Table 2 clearly showed that, increasing concentrations caused gradual significant increases in various growth parameters as shoot and root length, number of branches / plants, shoot fresh and dry weight and root fresh weight as compared with control plants, except, number of branches, shoot and root fresh weight the increases were non-significant with 50 mg/L compared with control plants. The most effective concentration was 75 mg/L it caused increasing in all growth indices except shoot length and fresh weight 100 mg/L was the most effective concentration. On the other hand, the effect on root dry weight showed different response as different concentrations decreased markedly root dry wt. as compared with control untreated plants.

3.2.2. Changes in photosynthetic pigments, IAA, phenolics and free amino acids contents

The changes in photosynthetic pigments of peanut plants in response to different concentrations of either phenyl alanine or aspartic acid were presented in Figure 3. Increasing concentration from 50 to 75 to 100 mg/L of phenyl alanine or aspartic acid increased gradually and significantly photosynthetic pigments compared with control plants. Increasing concentration from 50 to 75 to 100 mg/L recorded non-significant effect on chlorophyll a content of peanut plants. Moreover, 50 mg/L show the highest significant increases in Chlorophyll b and total pigments compared with other concentrations. While 100 mg/L gave the highest increase in carotenoids content as compared with other concentrations (Figure 3).

In addition, data in in Figure 3 presented IAA, phenolic and free amino acids contents of peanut in response to foliar concentrations of amino acids. IAA, phenolic and free amino acids showed gradually and significantly increased with increasing concentrations from 50 to 75 to 100 mg/L compared with control plants. The highest increased of IAA and phenolics were obtained by 75 mg/L while 100 mg/L gave the highest free amino acid content comparing with the other used concentrations (Figure 3).

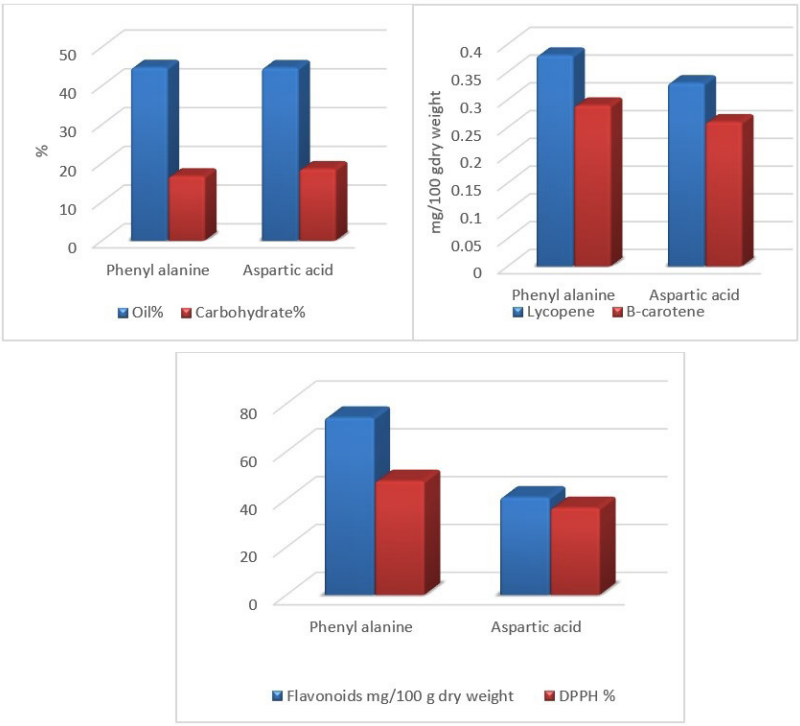

Figure 2. Effect of phenyl alanine or aspartic acid foliar treatments on Oil%, Carbohydrates%, Lycopene and β-Carotene contents (mg/100 g dry weight) and DPPH % activities in seeds of peanut plants grown under sandy soil. $LSD_{0.05}$: Oil% ns., carbohydrate%: 0.01, flavonoids: 0.30, Lycopene: 0.01, β-Carotene: 0.01 and DPPH%: 0.91.

Table 2. Effect of concentrations on growth, seed yield and its components of peanut plants grown under sandy soil (data are means of two seasons).

Traits	Concentrations (mg/L)				$LSD_{0.05}$
	0	50	75	100	
Shoot length (cm)	15.17	18.00	21.17	21.33	2.42
No. of branches/ plant	3.67	4.17	5.50	5.00	0.85
Shoot fresh weight (g)	45.89	71.78	108.45	109.44	27.30
Shoot dry weight (g)	22.18	34.29	45.80	40.67	8.28
Root length (cm)	8.50	10.67	11.67	11.50	1.03
Root fresh weight (g)	2.03	2.40	2.72	2.60	0.68
root dry weight (g)	1.52	1.06	0.99	0.95	0.31
Plant height (cm)	20.50	23.83	25.00	24.17	0.96
No. of branches/ plant	3.83	3.83	4.67	5.00	1.03
No. of pods/plant	26.00	28.00	27.00	30.17	3.86
No. of seeds/pod	2.00	2.17	2.50	2.50	0.43
Biological yield/plant (g)	56.18	81.61	86.11	95.89	3.58
Pod yield/ plant (g)	22.66	31.03	39.14	45.29	3.84
Seed yield/plant (g)	14.78	21.00	24.64	28.37	2.07
Shilling %	34.80	32.32	37.45	37.55	3.74
Oil yield (kg/fed.)	345.45	441.39	480.13	634.20	29.88
Biological yield (ton/fed.)	2.19	2.44	2.84	3.50	0.07
Seed yield (Kg/fed.)	812.25	988.98	1049.25	1392.73	65.63

3.2.3. Changes in seed yield and its components

Table2 showed the effect of different concentrations of either phenyl alanine or aspartic acid on seed yield and its components of peanut plants grown under sandy soil conditions. Data clearly show the promotive effect of different concentrations on increasing significantly seed and oil yields of peanut plants compared with untreated control plants. The most effective concentration was 100 mg/L in most of the studied parameters as compared with control plants. On the other hand, increasing the concentration from 75 to 100 mg/L the increases were not significant in plants height, No. of branches/plant, No. of pods/ plant, No. of seeds/pod and % of shilling.

3.2.4. Changes in nutritional values in seeds of peanut plants

Data in Figure 4 showed the significant effect of different concentrations (0.0, 50, 75. and 100 mg/L) on the nutritional value (oil%, carbohydrates%, flavonoids, lycopene, β-Carotene and DPPH activity) of the seeds of peanut plants, Data clearly showed there were significant and gradual increases in different studied nutritional

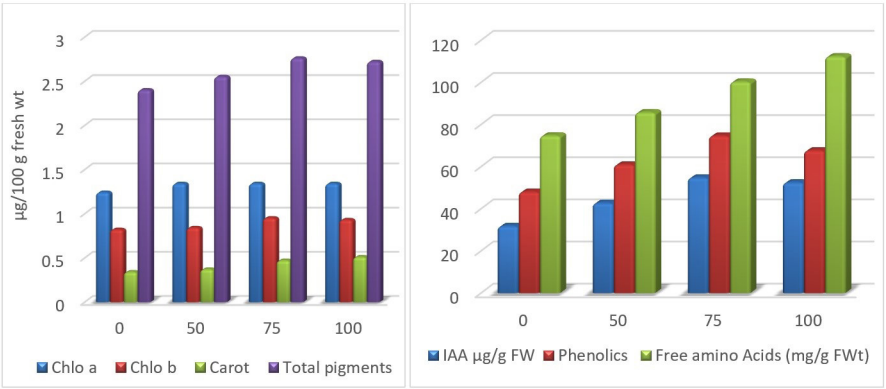

Figure 3. Effect of concentrations on photosynthetic pigments (µg/100 g fresh wt), IAA (µg/g FW), phenolics and free amino acids (mg/g FW) of peanut plant grown under sandy soil. LSD $_{5\%}$: Chl a: 0.04, Chl b: 0.02, Carot: 0.01, Total pig: 0.03. IAA: 0.25, Phenolic: 0.33 and free amino acids: 0.92.

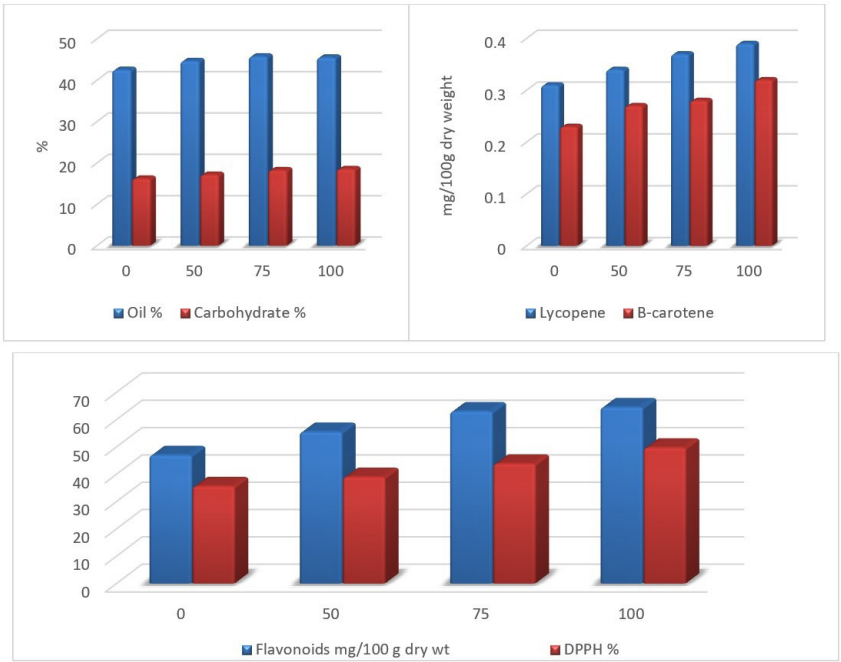

Figure 4. Effect of concentrations of phenyl alanine or aspartic acid on Oil%, Carbohydrates%, Lycopene and β-Carotene contents (mg/100 g dry weight) and DPPH % activities in seeds of peanut plants grown under sandy soil. LSD @ 5%: Oil% 0.13, carbohydrate%: 0.22, flavonoids: 0.40, Lycopene: 0.01, β-Carotene 0.01 and DPPH%: 0.70.

values of the seed yield of peanut plant with increasing concentrations as compared with untreated control plants. That means that the elevated concentration (100 mg/L) was the most effective treatment in both parameters.

3.3. Effect of interaction of phenyl alanine or aspartic acid with different concentrations on growth parameters, biochemical constituents, seed yield and its components of peanut plants

3.3.1. Changes on growth parameters

Data presented in Table 3 clearly showed the effect of foliar treatment of either phenyl alanine or aspartic acid with different concentrations (0.0, 50, 75 and 100 mg/L) on growth parameters of peanut plants grown under sandy soil. Data showed that, foliar different treatments caused significant and gradual increases in different studied growth parameters of peanut plants compared with those treated with control. The most effective concentration of phenyl alanine was 75 mg/L in most studied parameters. Meanwhile 100 mg/L was the most effective concentration of aspartic acid.

3.3.2. Changes in photosynthetic pigments, IAA, phenolics and free amino acids contents

Data presented in data in Figure 5 clearly showed the effect of foliar treatment of phenyl alanine or aspartic acid with different concentrations (0.0, 50, 75 and 100 mg/L) on photosynthetic pigments, IAA, phenolics and free amino acids contents of pea nut plant. Data show that, foliar treatment of different concentrations of both phenyl alanine or aspartic acid markedly increased in different studied photosynthetic pigments (chlorophyll a, chlorophyll b, Carotenoids, and total pigments), IAA, phenolic and free amino acids content. The most effective concentration of phenyl alanine was 75 mg/L in most studied parameters meanwhile 100 mg/L was the most effective concentration of aspartic acid.

3.3.3. Changes in seed yield and yield components

Data in Table 4 indicated that the seed yield, biological yield, and oil yield per feddan of peanut plants and its components increased significantly with increasing either phenyl alanine or aspartic acid concentrations from 50 to 100 mg/L. Foliar application of 100 mg/L phenyl alanine and aspartic acid increased seed yield/fed. by 56.61 and 90%, biological yield/Fed. by 60.96 and 58.57% and oil yield/fed by 63.3 and 104.16% respectively, over untreated control. These increases were due to the increase in seed yield/plant by (75.58 and 108.2%), biological yield/ plant by (55.51 and 87.8%), number of pods/ plant (36.1 and 28.91%), number of branches/ plant (16.75 and 80.18%) respectively, over the untreated plants (control).

3.3.4. Changes in nutritional value

Figure 6 showed the effect of different concentrations (0.0, 50, 75 and 100 mg/L) of either phenyl alanine or aspartic acid on the nutritional value (%of oil, %of carbohydrates, flavonoids, lycopene, β-Carotene, and DPPH activity) of the yielded seeds of peanut plant grown under

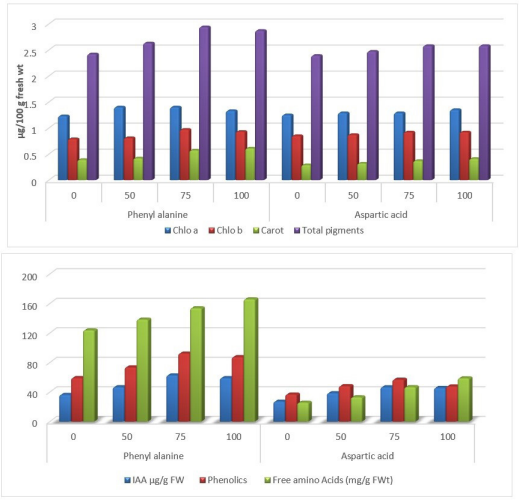

Figure 5. Effect of phenyl alanine or aspartic acid with different concentrations (0, 50, 75 and 100 mg/L) on photosynthetic pigments (µg/100 g fresh wt.), IAA (µg/g FW) and phenolic (mg/g FW) of peanut plants grown under sandy soil. LSD $_{5\%}$: Chl a: 0.06, Chl b: 0.03, Carot: 0.02, Total pig: 0.04. IAA: 0.36, Phenolic: 0.47 and free amino acids: 1.30.

Table 3. Effect of phenyl alanine or aspartic acid with different concentrations on growth parameters of peanut plants grown under sandy soil (data are means of two seasons).

Characters	Phenyl alanine				Aspartic acid				LSD $_{0.05}$
	0	50	75	100	0	50	75	100	
Shoot length (cm)	14.67	16.67	20.67	20.67	15.67	19.33	21.67	22.00	3.42
No. of branches/ plant	4.00	4.67	6.67	5.33	3.33	3.67	4.33	4.67	1.21
Shoot fresh weight (g)	49.66	64.34	97.74	74.13	42.11	79.22	119.15	144.74	38.61
Shoot dry weight (g)	24.43	35.52	46.73	30.61	19.92	33.05	44.87	50.72	11.70
Root length (cm)	8.67	9.33	11.00	11.00	8.33	12.00	12.33	12.00	1.46
Root fresh weight (g)	2.07	2.35	1.42	2.29	1.99	2.44	2.01	2.90	0.96
Root dry weight (g)	1.07	1.04	1.07	0.96	1.96	1.08	0.91	0.94	0.44

Table 4. Effect of phenyl alanine or aspartic acid with different concentrations (0, 50, 75 and 100 mg/L) on seed yield and its components of peanut plants grown under sandy soil (data are means of two seasons).

Characters	Phenyl alanine				Aspartic acid				$LSD_{0.05}$
	0	50	75	100	0	50	75	100	
Plant height (cm)	19.00	23.67	25.00	22.00	22.00	24.00	25.00	26.33	1.35
No. of branches/ plant	3.33	3.67	4.00	4.00	3.33	4.00	5.33	6.00	1.46
No. of pods/plant	20.33	22.67	24.33	27.67	27.67	31.33	32.67	35.67	8.29
No. of seeds/pod	2.00	2.00	2.33	2.67	2.00	2.33	2.67	2.33	0.76
Biological yield/plant (g)	59.56	67.71	69.01	92.62	52.80	95.52	103.20	99.16	5.06
Pod yield/ plant (g)	22.39	26.93	30.30	42.81	22.93	35.14	47.99	47.77	5.44
Seed yield/plant (g)	14.20	17.85	18.26	24.79	15.35	24.15	31.01	31.96	2.93
Shilling %	36.57	33.52	39.70	42.08	31.02	33.11	35.21	33.03	5.30
Oil yield (kg/fed)	347.85	396.20	366.72	568.05	343.05	486.58	593.53	700.36	42.26
Biological yield (ton/fed)	2.28	2.40	2.53	3.67	2.10	2.49	3.16	3.33	0.10
Seed yield (Kg/fed)	800.37	818.42	881.12	1253.49	806.13	1096.55	1298.37	1531.98	92.81

sandy soil. Data clearly show that foliar treatment of either phenyl alanine or aspartic acid with different concentrations increased significantly different studied nutritional values of the yielded seeds of peanut plantsas compared with untreated control plants. 75 mg/L was the most effective concentration on increasing % of oil, meanwhile, 100 mg/L gave the highest amounts of carbohydrate, flavonoids, lycopene, β-Carotene, and DPPH either by phenyl alanine or aspartic acid.

3.3.4.1. Fatty acid constituents

The presented data (Table 5) of gas chromatographic analysis of methyl esters of fatty acids of yielded peanut oil showed that, oleic acid (C18:1) and linoleic acid (C18:2) were the predominant unsaturated fatty acids as well as abundant fatty acids in all treatments and untreated plants. Meanwhile, palmitic acid (C16:0) was the predominant saturated fatty acid, followed by stearic acid (C18:0). Exogenous treatment of different concentrations of either phenyl alanine or aspartic acid improved fatty acid constituents by increasing unsaturated fatty acids and reduced saturated fatty acid comparing with untreated plants. Thus, the ratio of total unsaturated (TU) / total saturated (TS) were increased.

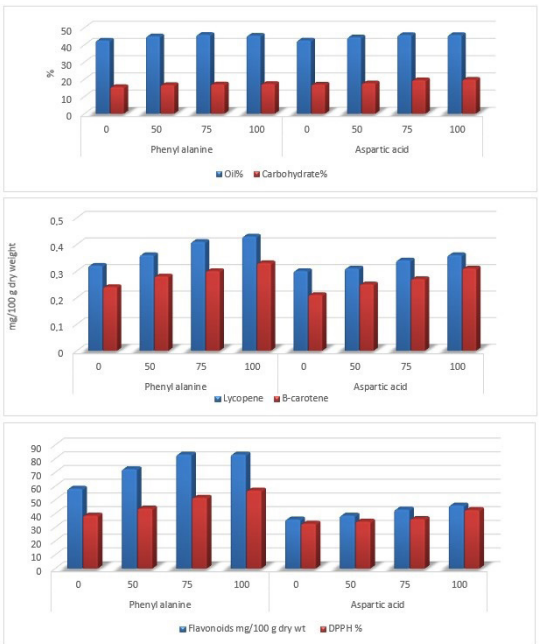

Figure 6. Effect of phenyl alanine or aspartic acid with different concentrations (0, 50, 75 and 100 mg/L) on oil%, carbohydrates%, flavonoids, lycopene, β-Carotene, and DPPH% of peanut plants grown under sandy soil. $LSD_{0.05}$: oil%: 0.18, carbohydrates%: 0.31, flavonoids: 0.56, lycopene:0.01, β-Carotene: 0.01 and DPPH%: 0.99.

4. Discussion

Amino acids in plants are implicated in primary and secondary metabolism, as well as a variety of cellular enzymatic activities as components of many enzymes. As a result, they could affect a variety of biochemical and physiological mechanisms, including plant vegetative growth, germination, fruit ripening, signaling and stimulation of defense systems versus abiotic and biotic stresses, osmo-regulation, reactive oxygen species inactivation, and as a nitrogen reserve source (Teixeira et al., 2017). Phenyl alanine or aspartic acid with different levels increased different studied growth indices and yield components of peanut plant (Tables 1 and 3). This is consistent with previous findings on different plant species Saburi et al. (2014) on basil, Bakry et al. (2018) on flax, Aghaei et al. (2019) using phenyl alanine on hyssop, Alfosea-Simón et al. (2021) using aspartic acid on tomato plants. Those amino acids have a significant impact on

Table 5. Effect of different concentrations of phenyl alanine or aspartic acid on fatty acid constituents of seeds oil and its components of peanut plants grown under sandy soil (data are means of two seasons).

Fatty acids	Control	Phenyl alanine (mg/L)			Aspartic acid (mg/L)		
		50	75	100	50	75	100
C16:0 (Palmitic acid)	10.76	9.27	9.16	9.85	9.68	9.85	9.67
C18:0 (Stearic acid)	3.25	3.05	2.95	2.75	2.68	2.42	2.62
C20:0 (Arachidic acid)	0.09	0.00	0.16	0.02	0.08	0.14	0.17
TS	14.10	12.32	12.27	12.62	12.44	12.41	12.46
C18:1 (Oleic acid)	37.62	38.62	39.79	38.95	40.51	40.85	39.35
C18:2 (Linoleic acid)	34.85	36.95	37.85	37.95	37.95	37.25	37.95
Oleic/Linoleic ratio	1.08	1.05	1.05	1.03	1.07	1.10	1.04
C18:3 (Linolenic acid)	3.12	3.35	3.45	3.75	3.95	4.26	4.85
TUS	75.59	78.92	81.09	80.65	82.41	82.36	82.15
TFA	89.69	91.24	93.36	93.27	94.85	94.77	94.61
TU/TS	5.36	6.41	6.61	6.39	6.62	6.64	6.59

TS: total saturated fatty acid; TUS: total unsaturated fatty acid; TFA: total fatty acid; TUS/TS: total unsaturated fatty acid/total saturated fatty acid.

growth-related metabolic activities via enhancing the ability of water uptake and usage and as well as, preserving photosynthetic pigments, which were significantly induced higher levels of IAA contents which improve cell division and/or cell enlargement (Figures 1, 3 and 5). The positive role of the utilized amino acids at a specific level in plants might be responsible for their promotional effect. They also regard as plant hormones like indole acetic acid as a source for nitrogen, carbon, energy, enzyme, co-enzymes as stated earlier (Goss, 1973; Ramadan et al., 2020). Moreover, Thom et al. (1981) stated that amino acids provide plant cells with an immediate source of nitrogen, which the cells typically consume faster than inorganic nitrogen. Amino acids play a crucial effect in plant and protein assimilation, which are crucial for cell formation and hence enhance fresh and dry matter which reflected in increasing plant growth consequently plant productivity.

Phenyl alanine or aspartic acid foliar application (50, 75 and 100 mg/L) improved peanut photosynthetic pigment components (Figures 1, 3 and 5). The results obtained data are consistent with those obtained by Bakry et al. (2018), Aghaei et al. (2019), Alfosea-Simón et al. (2021), Goss (1973) and Thom et al. (1981) using amino acids on different plant species. The function of amino acid in initiating the metabolic role leading to chlorophyll production and the succinyl COA (Kerb's cycle intermediate) could explain these increases in photosynthetic pigments (Taylor et al., 1982; Abdallah et al., 2020a, b). Furthermore, amino acids are also involved in the formation of organic compounds such as pigments, vitamins, alkaloids, enzymes, terpenoids, coenzymes, purine, and pyrimidine bases (Wu, 2009; Haroun et al., 2010). Amino acids like phenyl alanine and aspartic acid have 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 (Marschner, 2011).

In comparison with control plants, different doses of phenyl alanine or aspartic acid (50, 75 or 100 mg/L) enhanced endogenous IAA, phenol, and free amino acids. Aspartic acid addition boosted indole acetic acid in wheat plants according to the study of El-Awadi et al. (2019). The induction of IAA content in response to phenylalanine or aspartic acid is in parallel with the increase in growth rate (Table 1) revealing that endogenous hormones play a role in stimulating cell differentiation and/or cell enlargement and subsequently the growth (Taiz and Zeiger, 2013). Maxwell and Kieber (2004) verified the relationship between amino acids and the formation of growth regulating substances such as IAA. Regarding the phenolic compounds, the promotive effect of different treatments of phenyl alanine or aspartic acid may be attributed to that phenolic can act as defensive components of plant cells protecting cells from possible oxidative damage; improve cell membrane stability. Furthermore, Heldt and Piechulla (2010) showed that phenolic compounds are originate from amino acids.

Amino acids treatments led to significant increases in different nutritional values of seed yield of peanut (Tables 1, 2 and 3). These increases in yield and its components of peanut plants might be resulted from increased growth parameters, photosynthetic pigments contents thus reflecting on increased photosynthesis process resulting in increased transfer of photo-assimilates from leaves to seeds thus increased their weights which resulted in increased different yield components. Moreover, these increases could be due to increased endogenous growth regulators (as IAA). It is obvious that bioregulators tend to form sink mobilizing various nutrients, involved in biosynthesis new tissues in wheat plants and/or enhancing photosynthesis (Abd El-Hameid and Sadak, 2020).

Data in Figures 2, 4 and 6) showed that foliar application of phenyl alanine or aspartic acid amino acids increased significantly and gradually carbohydrate and oil contents of peanut seeds. This promotive effect of amino acids might be related resulted through their roles on enzymatic activity and translocation of metabolites from source (leaves) to the developed peanut seed (sink) (Abdallah et al., 2015).

The significant increases in carbohydrate contents may be related to the increased photosynthetic output of the used treatment (Taiz and Zeiger, 2013). The rise in oil contents may be related to increased vegetative growth and nutrients uptake (Bukhsh et al., 2009).

Regarding to antioxidant compounds (flavonoid, β-Carotene and lycopene contents) of peanut seed yield data showed that, their contents increased in response to different phenyl alanine and aspartic acid (Figures 2, 3, 4 and 6). These increases could be attributed to the increased biosynthesis and/or decreased degradation. Lycopene is regarded as a non-photosynthetic pigment, a valuable phytochemical and effective pigment and is well known for its strong potential as a good antioxidant molecule (Baranska et al., 2006). Lycopene as a precursor of β-carotene, which is a fat-soluble carotenoid exhibit twofold higher antioxidant activity than β-carotene (Sandmann, 1994). Long-chain conjugated double bonds (polyene chains) with an ability to quench free radicals and present in lycopene mainly attribute to its potent antioxidant ability (Britton, 1996). Other essential appointed lycopene roles include cell signaling and communications (Zhang et al., 1991). Furthermore, carotenoids are closely related to photosynthesis as a constituent of the light harvesting system, thus, under our current experimental conditions the increase in lycopene and β-carotene levels related to photosynthetic processes increases (Figures 1, 3 and 5). Regarding free radical scavenging activity (DPPH%) which has a major effect in the scavenging of increased levels of free radicales that cause oxidative damage in plant cells. The rise in total phenols and total flavonoids causes the antioxidant activity to increase (Žilić et al., 2011).

The positive effect of using amino acids on fatty acid constituents of peanut oil yield (Table 5) is consistent with Ramadan et al. (2019) findings by using L-arginine on sunflower plant and Bakry et al. (2020) by using tyrosine on peanut plants. These reductions in saturated fatty acids concomitant with the increases in unsaturated fatty acids. The increases in saturated fatty acids (oleic and linoleic acids) of peanut was proved to improve oil quality and these fatty acids are essential for human diet as they lower the risk of heart diseases related to cholesterol oxidation as well as, decrease low density lipoprotein (LDL) in human blood (Abd El-Hameid and Sadak, 2020).

5. Conclusion

Finally, it could be concluded that, foliar treatments of different concentrations of either phenyl alanine or aspartic acid (50, 75, 100 mg/L) improved all studied growth indices, photosynthetic pigments, IAA, phenol, and free amino acids contents in addition to seed yield and its components. Moreover, some nutritional contents (total carbohydrates and oil in percentage), antioxidant compounds (flavonoids, β-Carotene and lycopene) and antioxidant activities (as DPPH %) of the seed yield peanut.

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