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Research Article
Physiological Aspects of Tyrosine and Salicylic Acid on Morphological, Yield and Biochemical Constituents of Peanut Plants

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Abstract
Background and Objective: The L-tyrosine is one of the important natural amino acids used in promoting growth and productivity of various crops and used to build hormones. Salicylic acid (SA), is naturally produced compound with several promotive effects in plants. This study aimed to evaluate the physiological role of L-tyrosine and salicylic acid on growth, some biochemical aspects, yield and nutritional values of the peanut seeds under sandy soil conditions. **Materials and Methods:** During 2018 and 2019 summer seasons, 2 field trials were conducted at the Research and production Station of NRC, El-Nubaria Province, El-Beheira Governorate, Egypt. To study the physiological role of tyrosine and salicylic acid foliar treatment on vegetative growth (60 days after sowing, DAS), photosynthetic pigments in fresh leaves. Total carbohydrates, IAA (Indole acetic acid), flavonoids, β-carotene, lycopene, total phenol and enzyme activities (PAL and TAL) were determined in plant shoots. Moreover, yield and its components (Number of branches/plant, straw yield/plant, pod yield/plant, biological yield/plant, number of pods/plant, number of seeds/pod and seed yield/plant as well as seed quality (oil yield) and fatty acids of peanut grown under sandy soil conditions were recorded. **Results:** Results showed that, external treatment of L-tyrosine (50, 100 and 150 mg L^{-1}) and salicylic acid (100, 200 and 300 mg L^{-1}) increased significantly growth criteria and photosynthetic pigments, total carbohydrate, IAA and phenolic contents in shoots. In addition, yield and its components significantly increased with all treatments. The highest increases in seed yield (t ha^{-1}) and oil yield (t ha^{-1}) were recorded 14.45 and 144.93%, respectively when 100 mg L^{-1} tyrosine was applied. Moreover, all treatments caused significant increases in carbohydrate, oil, antioxidants compounds as flavonoids, β-carotene and lycopene contents, antioxidant activity and unsaturated fatty acids as compared with untreated control plants of the yielded peanut seeds. **Conclusion:** The L-tyrosine and salicylic acid has a regulatory role on growth, some biochemical aspects, yield quantity and quality as well as improve fatty acid composition of the yielded oil. The L-tyrosine with 100 mg L^{-1} was the best treatment on enhancing growth and productivity of peanut plant.

Key words: Peanut, fatty acids, endogenous indole acetic acid, oil content, salicylic acid, L-tyrosine, carbohydrates

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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

Peanut (*Arachis hypogaea* L.) is cultivated in Egypt for fresh human consumption, oil production or export. Peanut seeds are rich with nutritional values i.e., protein, lipids, minerals as calcium and magnesium and vitamins[1,2]. Peanut seeds are used in different forms, such as soup thickener where they double as nutritional enhancers, snacks when cooked, roasted, dried or fried. Recently, a peanut sprout was used as a new healthy vegetable. Since cultivation of peanut is thrived in the reclaimed sandy soil, thus, great attention should be attained to increase its cultivation in reclaimed sandy soil. Reclaimed sandy soil mostly suffer from different environmental adverse conditions such as, nutrient shortage, low availability of water, fluctuation of temperature between day and night and high irradiances[3]. Therefore, it is very important to increase peanut tolerance to these unsuitable environmental conditions through several strategies. These strategies include selection of high tolerance new genotypes with high yielding ability, applying the most effective agricultural practices and/or using external application with different natural growth promoting substances. Promoting substances as plant growth regulators, amino acids, vitamins and antioxidants etc., which offer a great opportunity to improve growth and productivity of peanut plant.

Amino acids are one of these important natural compounds used in promoting growth and productivity of various crops[4]. One of these amino acids is L-tyrosine. The L-tyrosine is the hydroxyl phenol acid that is used to build hormones, proteins and used as an important source for different plant components. It is considered as precursors of thousands of vital and specialized compounds in plant cells. It plays a vital role for tyrosine-derived metabolites, like vitamin-E, plant phenolic compounds, cyanogenic glycosides and suberin which have crucial roles in plant fitness[5]. Moreover, it has a role in signaling cascades by acting as signal molecules or by mediating the conjugation between amino acids and phytohormones to change hormone levels[6]. They can act as stress-reducing agents[7-9]. Earlier researcher has shown the efficiency of amino acids uptake by plants[10-12].

Another natural produced compound in plants is salicylic acid (SA), it presents slightly in plant cells. The SA plays a vital role for improving response of plants against various environmental stressors where act as a hormone-like substance and a signaling or messenger molecule in plant. It also plays a positive vital role for improving ion uptake and transport, permeability of membrane, rate of photosynthetic, transpiration, plant growth and development[13,14]. Senaratna *et al.*[15] reported that the effect of SA depends on its concentration, method and time of application, environmental conditions, plant species and plant growth stage. Many studies reported that foliar application of SA has been shown to enhance plant growth as well as biomass and yield in a variety of plant species[16-19]. So, the present work was designed in order to compare between the potential effects of different applied tyrosine at 0, 50, 100 and 150 mg L^{-1} and salicylic acid at 0, 100, 2100 and 300 mg L^{-1} on the vegetative growth, some biochemical aspects, yield and quantity and quality of peanut plants.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of National Research Center, (latitude 30°30'1.4"N, longitude 30°19'10.9"E and 21 m+MSL (mean sea level) at (NRC), Al Nubaria district, El-Beheira Governorate, Egypt, during 2 successive summer seasons of 2018 and 2019 to study the physiological role of tyrosine and salicylic acid foliar treatment on vegetative growth, photosynthetic pigments, yield and its components as well as seed quality of peanut under sandy soil conditions.

The experimental soil (0-30 depth) was analyzed according to the method described by Jackson[20]. 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 complete randomized block design in 3 replications, where the antioxidant two materials were used as foliar applications at rates of tyrosine (0.0, 50, 100 and 150 mg L^{-1}) and salicylic acid (0.0, 100, 200 and 300 mg L^{-1}) were randomly applied twice, after 30 and 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).

Peanut (*Arachis hypogaea* L.) variety Gize-6 were procured from Oil Crops Research Department, Field Crops Research Institute, Agricultural Research Center, Giza Egypt. It was inoculated just before sowing with the specific rhizobium bacteria inoculants. Seeds of peanut were sown in the first week of May, 2018 and 2019. Phosphorus fertilizer, as calcium superphosphate (15.5% P_2O_5) was added during the seed bed preparation at rate of 146.4 kg P_2O_5 ha^{-1}. Potassium sulphate (48% K_2O) at the rate of 120 kg ha^{-1} was applied at sowing. Nitrogen fertilizer was added at a rate of 72 kg N ha^{-1} as ammonium sulfate (20.60% N) in 2 equal doses, 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. Groundnut was manually harvested on September 25th at both seasons.

Recording of data: The data pertaining to morphology of vegetative growth, photosynthetic pigments, yield components and seed oil percentage.

Vegetative growth: A random sample of 5 plants were randomly taken from each plot to determine growth parameters at 60 days after sowing i.e., shoot and root length (cm), branches (number/plant), shoot fresh and dry weights (g/plant), root length (cm), root fresh and dry weights (g/plant).

Yield and yield components characters: A random sample of 5 plants was assigned for investigation in each plot. The plants were taken from the middle region of the plot at harvest time, data on yield characters were recorded as follows.

Number of branches/plants, straw yield/plant (g), pods yield/plant (g), biological yield/plant (g), number of pods/plants, number of seeds/pods, seed yield/plant (g). Whole plot was harvested and the pods were air dried to calculate biological yield (t ha^{-1}), seed yield (t ha^{-1}) and oil yields were calculated t ha^{-1}.

Chemical analysis

Shoot system

Photosynthetic pigments: Total chlorophyll a, b and carotenoids contents in fresh leaves were estimated using the method of Lichtenthaler and Buschmann[21]. Total carbohydrate was carried out according to Prud'homme *et al.*[22]. Indole acetic acid content was extracted and analyzed by the method of Larsen *et al.*[23]. Total phenol content was measured as described by Danil and George[24]. The extraction and assay of phenylalanine ammonia lyase (PAL, EC, 4.3.1.1) and tyrosine ammonia lyase (TAL, EC, 4.3.1), enzymes activities were carried out according to the method adopted by Beaudoin-Eagan and Thorpe[25].

Seeds: Seed oil content was determined by using Soxhlet extraction apparatus using petroleum ether as a solvent and then the seed oil percentage was calculated on dry weight basis according to AOAC[26]. Analysis of fatty acids was determined from seed oil specimens of the second season according to Vogel (1975). The GLC was carried out under the same conditions[27]. Carbohydrate (%), flavonoids contents were determined by the aluminum chloride colorimetric assay as described by Ordonez *et al.*[28], The method used for determination of lycopene and β-carotene as described by Nagata and Yamashita[29] and DPPH was determined according to Gyamfi *et al.*[30].

Statistical analysis: All data were statistically analyzed according to Snedecor and Cochran[31]. The least significant differences ($LSD_{5\%}$) were used to compare the means.

RESULTS

Growth parameters: Different treatments of foliar applications of tyrosine (50, 100 and 150 mg L^{-1}) and salicylic acid (100, 200 and 300 mg L^{-1}) caused significant and gradual increases in different growth criteria (Shoot and root length, branches number/plant, shoot, root fresh and dry weight) up to 100 mg L^{-1} tyrosine and 200 mg L^{-1} salicylic acid thereafter the different studied criteria values decreased but still greater than control plants (Table 1). Data clearly showed that, 100 mg L^{-1} tyrosine and 200 mg L^{-1} of salicylic acid were the most effective concentration for the most of studied growth criteria. Application of 100 mg L^{-1} tyrosine increased shoot length, branches number/plant, shoot fresh and dry weight, root length, fresh and dry weight by 65, 70, 355, 254, 37, 137 and 125%, respectively. Foliar treatment of tyrosine was more effective than salicylic acid on increasing the most studied growth criteria of peanut plants.

Table 1: Effect of tyrosine and salicylic acid application on growth criteria of peanut plant grown under sandy soil

Treatments	Branches (number/plant)	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	Root Length (cm)	Root Fresh weight (g)	Root Dry weight (g)
Control (0.0)	9.0±0.58	30.7±0.88	41.80±2.98	12.3±0.21	9.7±0.88	2.39±0.03	0.89±0.02
L-tyrosine (mg L^{-1})							
50	12.7±1.20	49.7±0.33	162.30±3.62	38.9±1.46	13.7±0.33	4.32±0.50	1.07±0.32
100	15.3±1.45	50.7±0.88	190.60±9.32	43.6±3.21	13.3±0.88	5.67±0.50	2.01±0.08
150	14.0±0.58	36.0±0.67	133.10±2.98	34.9±1.44	14.0±0.33	5.11±0.14	1.17±0.03
Salicylic acid (mg L^{-1})							
100	13.3±1.20	34.7±0.33	94.50±6.43	17.0±4.29	9.7±1.20	4.11±0.55	1.60±0.03
200	13.3±0.33	39.7±1.20	119.00±9.66	40.9±0.99	11.7±0.33	4.11±0.07	1.51±0.05
300	11.0±0.58	36.3±0.58	99.80±3.37	21.2±2.75	11.3±0.58	2.39±0.18	0.87±0.02
$LSD_{5\%}$	3.05	2.29	5.72	7.56	1.99	1.05	0.41

Each value represents the mean of 3 replicates±standard error, data are means of 2 seasons

Table 2: Effect of tyrosine and salicylic acid application on photosynthetic pigments (µg g^{-1} fresh weight) of peanut plant grown under sandy soil

	Photosynthetic pigments (µg g^{-1}/fresh weight)			
Treatments	Chlorophyll a	Chlorophyll b	Carotenoids	Total pigment
Control (0.0)	0.89±0.005	0.57±0.001	0.27±0.002	1.63±0.002
L-tyrosine (mg L^{-1})				
50	0.92±0.002	0.61±0.003	0.30±0.003	1.83±0.002
100	0.95±0.001	0.63±0.003	0.33±0.005	1.91±0.002
150	0.94±0.001	0.63±0.001	0.35±0.001	1.92±0.000
Salicylic acid (mg L^{-1})				
100	0.94±0.004	0.60±0.003	0.29±0.000	1.83±0.007
200	0.96±0.005	0.63±0.002	0.32±0.001	1.91±0.005
300	0.95±0.004	0.61±0.000	0.31±0.001	1.87±0.001
$LSD_{5\%}$	0.010	0.007	0.006	0.012

Each value represents the mean of 3 replicates±standard error

Table 3: Effect of tyrosine and salicylic acid application on total carbohydrate (%) (CHO), IAA (µg/100 g fresh weight and phenolic contents (mg/100 g dry weight) of peanut plant grown under sandy soil

Treatments	Total carbohydrate (%)	IAA (µg/100 g fresh weight)	Phenols (mg/100 g fresh weight)
Control (0.0)	14.05±0.23	33.25±0.16	36.99±1.07
L-tyrosine (mg L^{-1})			
50	16.49±0.02	59.16±0.29	57.66±1.52
100	17.77±0.06	68.31±0.38	79.64±1.37
150	16.38±0.00	57.10±0.15	78.31±2.08
Salicylic acid (mg L^{-1})			
100	15.16±0.09	49.79±1.61	54.49±2.17
200	15.69±0.05	59.75±0.59	76.33±2.39
300	14.96±0.10	54.25±0.34	49.93±3.67
$LSD_{5\%}$	0.36	1.98	7.273

Each value represents the mean of 3 replicates±standard error

Table 4: Effect of tyrosine and salicylic acid application on PAL and TAL (U min^{-1} g^{-1}/fresh weight) of peanut plant grown under sandy soil

Treatments	PAL (U min^{-1} g^{-1}/fresh weight)	TAL (U min^{-1} g^{-1}/fresh weight)
Control (0.0)	1.36±0.006	3.90±0.023
L-tyrosine (mg L^{-1})		
50	3.75±0.008	5.69±0.035
100	5.94±0.013	7.58±0.033
150	4.83±0.102	6.50±0.024
Salicylic acid (mg L^{-1})		
100	3.55±0.059	4.62±0.023
200	4.79±0.002	6.39±0.048
300	4.55±0.018	6.18±0.017
$LSD_{5\%}$	0.151	0.106

Each value represents the mean of 3 replicates±standard error

Photosynthetic pigments: Data in Table 2 showed that tyrosine (50, 75 and 100 mg L^{-1}) or salicylic acid foliar application (100, 150 and 200 mg L^{-1}) caused significant increases in chlorophyll a and b, carotenoids and consequently total pigments of peanut plant.

Different concentrations of tyrosine treatments were more effective than salicylic concentrations on enhancing different photosynthetic pigments. The highest positive effect was obtained from 200 mg L^{-1} of salicylic acid application in chlorophyll a meanwhile tyrosine with 150 mg L^{-1} has the highest increased effect on chlorophyll b, carotenoids and total pigments contents.

Indole acetic acid (IAA), total carbohydrates and phenolic contents: Data in Table 3 showed that, foliar application of L-tyrosine (i.e., 50, 75 and 100 mg L^{-1}) or salicylic acid (100, 200 and 300 mg L^{-1}) caused significant increases in IAA, total carbohydrates and phenolic contents of peanut plant as compared with untreated plants. The most pronounced treatment was 100 mg L^{-1} tyrosine on increasing IAA, total carbohydrates and phenolic contents as compared with other used treatments.

Phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) enzymes: The changes in activities of PAL and TAL enzymes of peanut plant affected by external treatment of tyrosine or salicylic acid different concentrations were recorded in Table 4. Data showed that, foliar treatment of tyrosine (50, 75 and 150 mg L^{-1}) or salicylic acid (100, 200 and 300 mg L^{-1}) increased significantly PAL and TAL activities as compared with untreated plants. The most effective treatment on increasing PAL and TAL enzyme activities was 100 mg L^{-1} tyrosine as compared with different treatment.

Table 5: Effect of tyrosine and salicylic acid application on yield, yield components of peanut plant grown under sandy soil

					Yield (g/plant)		
Treatments	Branches (number/plant)	Pods (number/plant)	Seeds (number/pod)	Biological	Straw	Pods	Seeds
Control (0.0)	12.00±0.58	23.33±1.20	2.00±0.04	69.04±2.86	38.70±2.18	30.34±2.56	25.07±1.30
L-tyrosine (mg L^{-1})							
50	17.00±0.58	42.67±4.12	2.33±0.03	101.88±3.42	53.18±2.10	48.70±2.96	35.26±1.38
100	18.33±0.88	46.00±1.53	3.00±0.05	141.28±1.77	64.86±1.03	76.42±1.24	54.00±1.47
150	16.33±1.20	33.33±0.67	2.67±0.11	89.45±3.94	42.28±1.45	47.17±2.51	34.61±2.11
Salicylic acid (mg L^{-1})							
100	15.67±1.20	34.00±3.06	2.33±0.03	98.27±3.36	40.94±3.83	47.33±0.86	34.47±1.16
200	16.67±0.88	29.67±1.20	2.67±0.07	107.15±3.99	47.75±4.27	58.40±5.20	46.24±2.29
300	15.67±0.88	30.33±2.40	2.33±0.03	86.11±2.04	40.95±4.31	45.16±1.85	33.14±0.83
$LSD_{5\%}$	2.97	9.41	0.88	11.26	7.60	7.98	3.33

Each value represents the mean of 3 replicates±standard error, data are means of 2 seasons

Table 6: Effect of tyrosine and salicylic acid application on biological, seed and oil yields and carbohydrate (%) of peanut plant grown under sandy soil

	Yield (kg ha^{-1})		
Treatments	Biological	Seeds	Oil
Control (0.0)	8.49±0.36	3.09±0.02	1.24±0.02
L-Tyrosine (mg L^{-1})			
50	12.41±0.26	4.37±0.03	1.90±0.03
100	15.32±0.53	6.69±0.06	3.03±0.01
150	10.88±0.46	4.25±0.05	1.84±0.03
Salicylic acid (mg L^{-1})			
100	9.24±0.38	4.20±0.04	1.81±0.00
200	14.73±0.66	5.68±0.03	2.60±0.02
300	10.17±0.37	4.07±0.04	1.90±0.02
$LSD_{5\%}$	0.46	0.13	0.06

Each value represents the mean of 3 replicates±standard error, data are mean of 2 seasons

Yield and its components: Data in Table 5 and 6 clearly showed that, different treatments significantly increased peanut yield and its components such as branches, pods (number/plant), seeds (number/pod), biological, straw, pods and seeds weight (g/plant, Table 5), biological, seed and oil yield (kg ha^{-1}, Table 6) as compared to control treatment. The maximum increases in biological, seed and oil yield (kg ha^{-1}) were obtained in response to foliar application of 100 mg L^{-1} of tyrosine. Application of 100 mg L^{-1} tyrosine treatment came in the first order followed by 200 mg L^{-1} salicylic acid for more values of peanut yield and its components compared to the other treatments. The percentages of increases in biological, seed, oil yield (t ha^{-1}) and oil (%) were 80.46, 116.29, 144.93 and 14.45% in response to 100 mg L^{-1} tyrosine (Table 6), meanwhile these percentages were 73.56, 83.69, 110.25 and 13.10%, respectively in response to 200 mg L^{-1} salicylic acid (Table 6).

Nutritional value, antioxidant compounds and antioxidant activities of peanut seeds: The changes of some nutritional contents (total carbohydrates and oil percentages), antioxidant compounds (flavonoids, β-carotene and lycopene) and antioxidant activities (as DPPH%) are recorded in Table 7. Data clearly showed the improving effect of different external treatments either tyrosine or salicylic acid on peanut quality of yielded seeds. The L-tyrosine different concentrations (50, 100 and 150 mg L^{-1}) and salicylic acid (100, 200 and 300 mg L^{-1}) increased significantly carbohydrate (%), oil (%), flavonoids, β-carotene, lycopene contents as well as the DPPH activities of the yielded seeds of peanut plants as compared to untreated plants. Peanut treatment with 100 mg L^{-1} was the most effective treatment as it gave the highest increases in all the above-mentioned parameters (Table 7).

Fatty acid composition: Gas chromatographic analysis of methyl esters of fatty acids of the yielded peanut oil showed that foliar spray of different concentration of L-tyrosine or salicylic acid improved fatty acid constituents via increasing unsaturated fatty acids and decreased saturated fatty acids as compared with untreated plants (Table 8). So, the ratio of total unsaturated (TU)/total saturated (TS) was increased. Palmitic acid (C16:0) was the predominant saturated fatty acids, followed by stearic acid (C18:0) meanwhile, oleic acid (C18:1) and linoleic acid (C18:2) were the most abundant fatty acids in all treatments. Moreover, oleic/linoleic and total unsaturated total saturated were increased in response of different concentrations of tyrosine or salicylic acid.

Table 7: Effect of tyrosine and salicylic acid application on carbohydrate (%), oil (%), flavonoids, β-carotene, lycopene ($\mu g\ g^{-1}$) and DPPH (%) activity of the yielded seed of peanut plant grown under sandy soil

Treatments	Carbohydrates (%)	Oil (%)	Flavonoids ($\mu g\ g^{-1}$)	B-carotene ($\mu g\ g^{-1}$)	Lycopene ($\mu g\ g^{-1}$)	DPPH (%)
Control (0.0)	17.08±0.08	39.99±0.19	42.14±0.29	0.327±0.001	0.357±0.003	41.50±0.87
L-tyrosine (mg L^{-1})						
50	18.93±0.06	43.39±0.29	65.99±0.38	0.355±0.004	0.391±0.001	43.99±0.53
100	19.69±0.19	45.77±0.19	81.39±0.44	0.418±0.001	0.412±0.003	46.74±0.25
150	18.82±0.11	45.24±0.24	74.83±0.69	0.389±0.003	0.400±0.000	45.12±0.28
Salicylic acid (mg L^{-1})						
100	18.05±0.15	43.15±0.14	58.92±0.33	0.344±0.002	0.368±0.002	43.85±0.17
200	19.29±0.19	45.23±0.24	75.84±0.29	0.393±0.003	0.410±0.001	46.60±0.15
300	18.63±0.17	44.24±0.36	68.37±0.72	0.347±0.002	0.383±0.001	44.74±0.26
$LSD_{5\%}$	0.31	0.54	1.59	0.012	0.006	0.49

Each value represents the mean of 3 replicates±standard error

Table 8: Effect of tyrosine and salicylic acid application on fatty acids contents of the yielded seed of peanut plant grown under sandy soil

		L-tyrosine (mg L^{-1})			Salicylic acid (mg L^{-1})		
Fatty acids	Control	50	100	150	100	200	300
C16:0	10.3±0.56	9.36±0.45	9.57±0.06	10.01±0.08	10.49±0.07	10.40±0.08	9.56±0.05
C18:0	3.41±0.21	3.41±0.35	3.20±0.07	2.52±0.04	2.08±0.04	2.35±0.03	2.97±0.04
C20:0	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.12±0.02	0.16±0.02
TS	13.75±0.85	12.77±0.75	12.77±0.42	12.53±0.08	12.57±0.35	12.87±0.07	12.69±0.16
C18:1	36.23±1.32	37.78±0.94	39.42±0.49	38.26±0.15	37.98±0.62	38.16±0.13	38.68±0.14
C18:2	35.47±1.24	37.17±0.74	36.59±0.42	36.00±0.21	36.70±0.53	35.37±0.25	34.41±0.42
Oleic/linoleic	1.02±0.06	1.02±0.12	1.08±0.07	1.06±0.06	1.03±0.03	1.02±0.01	1.06±0.03
C18:3	2.55±0.45	2.28±0.19	2.92±0.08	3.47±0.05	3.90±0.10	4.20±0.04	4.22±0.05
TUS	74.25±1.32	77.23±1.32	78.93±0.95	77.73±0.62	78.58±0.86	79.73±0.74	79.31±0.78
TFS	88.00±2.04	90.00±1.02	91.70±0.75	90.76±0.51	91.15±0.67	92.60±0.86	92.00±0.85
TU/TS	5.40±0.65	6.05±0.09	6.18±0.08	6.20±0.14	6.25±0.09	6.20±0.13	6.25±0.14

Each value represents the mean of 3 replicates±standard error, C16:0: Palmitic acid, C18:0: Stearic acid, C20:0 Arachidic acid, C18:1: Oleic acid, C18:2: Linoleic acid, C18:3: Linolenic acid, TS: Total saturated fatty acid, TUS: Total unsaturated fatty acid, TFA: Total fatty acid, TU/TS: Total unsaturated/total saturated fatty acid

DISCUSSION

Foliar treatment of tyrosine or salicylic acid increased growth criteria of peanut plant grown under sandy soil (Table 1). Application of tyrosine or salicylic acid increased growth values of peanut plant through increasing photosynthetic pigments (Table 2) and endogenous promoters especially IAA and carbohydrate contents (Table 3). These responses of tyrosine and salicylic acid treatments could be attributed to the increased levels of endogenous hormones consequently stimulation of cell division and/or cell enlargement and subsequently improved growth. Similar to the results of tyrosine[32-34].

A notable increase of photosynthetic pigments was detected in peanut grown under sandy soil treated with either L-tyrosine or salicylic acid is represented in (Table 2). These results of amino acid treatment were confirmed by the earlier findings on different plant species[16,34,35]. The positive role of L-tyrosine on improving chlorophyll a and b, carotenoids contents might be due to the succinyl COA (Kreb's cycle intermediate) as well as, it enhances the biosynthetic pathway leading to chlorophyll formation[36]. Dawood *et al.*[19] stated that, salicylic acid application significantly increased chlorophyll a and b, carotenoids and total chlorophylls of flax plant. Moreover, the potential effects of salicylic acid and its precursors' L-tyrosine amino acid may be attributed to the decrease in chlorophyll loss due to its ability to increase the antioxidant capacity of plant or inducing the synthesis of stabilizing substances[37].

The increases in total carbohydrates contents of peanut plant treated with either tyrosine or salicylic acid showed the same trend obtained previously on vegetative growth and photosynthetic pigments. These results are in agreement with the finding of other studies on different plants[38,39]. In addition, the increases in total carbohydrates might be related to the increased photosynthetic pigments which increase the rate of photosynthesis and carbohydrate synthesis[40].

Foliar application with different concentrations of tyrosine or salicylic acid caused significant increases in IAA contents. It is obvious that, the increases in endogenous IAA content concurrent with the increase in growth rate (Table 1) and this confirmed the role of the endogenous hormones in inducing cell division and/or cell enlargement and subsequently enhancing plant growth[41-43]. Moreover, the increased IAA contents could be attributed to the enhancing of biosynthesis and/or decreases their degradation and conjugation[19].

External treatment of tyrosine or salicylic acid increased significantly phenol contents of peanut plant. Tyrosine, is claimed to have an enhancing effect on phenolic substances. This enhancing role on different plants[44,45]. Also, Heldt and Piechulla[46] stated that phenolic compounds are derived from amino acids thus treatment with salicylic acid and its precursor increased total phenolic contents. Moreover, the increases in phenolic contents in plants treated with salicylic acid could be due to the phenolic nature of this compound[17]. Therefore, it could be expected that their application on plants increased phenolic concentration as previously confirmed on linseed plant[12], on soybean[17] and on lupine plant[39].

Phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) are considered regulatory enzymes in the phenylpropanoid pathway. PAL is one of the key enzymes in controlling phenolics biosynthesis from phenylalanine. Also, TAL, another enzyme involved in phenols synthesis[47]. Different treatments of tyrosine and SA increased PAL and TAL activities (Table 4). The obtained data are in agreements with those obtained[48] on sweet basil plant. The obtained data showed that secondary metabolites in plants could be accumulated by inducing the phenylpropanoid pathway without any stresses[48-51].

The improving in yield and its components of peanut plant by L-tyrosine or SA treatment might be resulted from the increases in growth (Table 1), photosynthetic pigment contents (Table 2) which could lead to increases in the photosynthesis process resulting in greater transfer of photo-assimilates to seeds and causing increases in their weights which resulted in increased number of branches/plant, pods and seeds number/plant and seed yield/plant (Table 5). In addition, the increase in yield might be due to the increase endogenous hormones (Table 3). It is evident that plant growth regulators seemed to form sink mobilizing the different nutrients, which are involved in building new tissues in wheat plants and/or enhance photosynthesis[16]. In addition, SA positively affects ion uptake and transport, membrane permeability and transpiration[14], photosynthetic and growth rates[52], increases CO_2 assimilation likely responsible for the increased plant growth[53]. Moreover, salicylic acid (SA) as a natural signal molecule, has been shown to play an important role in regulating a number of physiological processes in plants. Its exogenous application has promoted plant performance under biotic and abiotic stresses[15].

Different concentrations of tyrosine or salicylic acid increased significantly and gradually carbohydrate and oil contents of peanut seeds. Application of tyrosine on basil has resulted increase total oil. Similarly, salicylic acid treatment increased the nutritive value of linseed, soybean and flax plants respectively[16,17,54]. The promotive effect of tyrosine and salicylic acid could be resulted via their effects on enzymatic activity and translocation of the metabolites to the developed peanut seed. The substantial increase in carbohydrate contents could be resulted by the increased photosynthetic machinery due to the promotive effects of the used treatment on photosynthetic process. The increment in oil contents might be due to the increase in vegetative growth and nutrients uptake[55].

Antioxidant compounds (flavonoid, β-carotene and lycopene contents) levels increased in peanut seeds in response to different tyrosine and salicylic acid (Table 7). Such increases might be due to the phenolic nature of salicylic acid and its precursor tyrosine[56]. So, it might be deduced that their external treatment on plants induced flavonoid and phenolic increases as reported earlier on linseed[16]. Lycopene is considered a non-photosynthetic pigment which is an important phytochemical and it is well known for its significant potential to serve as a remarkable antioxidant molecule[57]. Other important assigned functions imparted by lycopene include cell signaling and communications[58] modulation of hormonal and immune response and role in metabolic pathways[59]. In addition, carotenoids are intimately linked with photosynthesis as a part of the light harvesting system, thus, under our prevailing experimental conditions the increases in lycopene and β-carotene contents may relate to the increase in photosynthetic processes (Table 2). With respect to free radicals scavenging activity (DPPH) which play an important role in scavenging increased level of free radicles which cause oxidative damage in plant cell.

The promotive effect of either tyrosine or salicylic acid on fatty acids constituents of peanut yielded oil (Table 8) are quite concurrent with those obtained using salicylic acid on flax plant[16,54]. The decreases in saturated fatty acids accompanied with the increases in unsaturated fatty acids enhanced oil quality[60]. 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[16].

SIGNIFICANCE STATEMENT

This study explores the beneficial effect of treatment with tyrosine or salicylic acid on peanut plants grown under reclaimed sandy soils. It also, explain some physiological aspects of these compounds and their correlation with capability of plants to facing unfavorable conditions at reclaimed sandy soils. This study will help the researcher to understand the role of these compounds on peanut plants grown under field conditions. However, further studies must be done to evaluate the physiological effects of either tyrosine or salicylic acid on peanut plant grown under reclaimed sandy soil at molecular level (i.e., enzyme, protein picture...etc).

CONCLUSION

The results showed that, foliar application of different concentrations of L-tyrosine (50, 75 and 100 mg L^{-1}) or salicylic acid (100, 200 and 300 mg L^{-1}) enhanced all studied growth criteria as well as photosynthetic pigments, total carbohydrates, IAA and phenol contents in addition to yield and its components. Moreover, some nutritional contents (total carbohydrates and oil (%)), antioxidant compounds (flavonoids, β-carotene and lycopene) and antioxidant activities (as DPPH (%)) of the yielded peanut seeds. It could be conclude that L-tyrosine and SA can play important roles to promote growth and productivity of peanut plant especially in claimed sandy soil via regulating physiological and biochemical processes.

REFERENCES

1. Savage, G.P. and J.I. Keenan, 1994. The Composition and Nutritive Value of Groundnut Kernels. In: The Groundnut Crop: Scientific Basis for Improvement, Smart, J. (Ed.). Chapman and Hall, London, UK., pp: 173-213.
2. Knauft, D.A. and P. Ozias-Akins, 1995. Recent Methodologies for Germplasm Enhancement and Breeding. In: Advances in Peanut Science, Pattee H.E. and H.T. Stalker (Eds.). Chapter 3, American Peanut Research and Education Society, Oklahoma, USA., pp: 54-94.
3. Dawood, M.G., M.S. Sadak, B.A. Bakry and M.F. El Karamany, 2019. Comparative studies on the role of benzoic, t-cinnamic and salicylic acids on growth, some biochemical aspects and yield of three flax cultivars grown under sandy soil conditions. Bull. Natl. Res. Centre, Vol. 43. 10.1186/s42269-019-0152-4.
4. Kamar, M.E. and A. Omar, 1987. Effect of nitrogen levels and spraying with aminal-forte (amino acids salvation) on yield of cucumber and potatoes. J. Agric. Sci. Mansoura Univ., 12: 900-907.
5. Herrmann, K.M. and L.M. Weaver, 1999. The shikimate pathway. Ann. Rev. Plant Physiol. Plant Mol. Biol., 50: 473-503.
6. Tegeder, M. and J.M. Ward, 2012. Molecular evolution of plant AAP and LHT amino acid transporters. Front. Plant Sci., Vol. 3. 10.3389/fpls.2012.00021.
7. Zhao, Y., 2010. Auxin biosynthesis and its role in plant development. Annu. Rev. Plant Biol., 61: 49-64.
8. 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.
9. Maeda, H. and N. Dudareva, 2012. The shikimate pathway and aromatic amino acid biosynthesis in plants. Annu. Rev. Plant Biol., 63: 73-105.
10. Gioseffi, E., A.D. Neergaard and J.K. Schjorring, 2012. Interactions between uptake of amino acids and inorganic nitrogen in wheat plants. Biogeosciences, 9: 1509-1518.
11. Sadak, M.S., S.A. Orabi and A.B. Bakry, 2015. Antioxidant properties, secondary metabolites and yield as affected by application of antioxidants and banana peel extract on Roselle plants. Am.-Eurasian J. Sustain. Agric., 9: 93-104.
12. Bakry, B.A., H.M.S. El-Bassiouny, M.S. Sadak and A.S.M. Younis, 2018. Yield, quantity and quality of two flax cultivars affected by phenylalanine and methionine under sandy soil conditions. Biosci. Res., 15: 3826-3842.
13. Gunes, A., A. Inal, M. Alpaslan, N. Cicek, E. Guneri, F. Eraslan and T. Guzelordu, 2005. Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). Arch. Agron. Soil Sci., 51: 687-695.
14. Simaei, M., R.A. Khavari-Nejad and F. Bernard, 2012. Exogenous application of salicylic acid and nitric oxide on the ionic contents and enzymatic activities in NaCl-stressed soybean plants. Am. J. Plant Sci., 3: 1495-1503.
15. Senaratna, T., D. Touchell, E. Bunn and K. Dixon, 2000. Acetyl salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Plant Growth Regul., 30: 157-161.
16. Bakry, B.A., D.M. El-Hariri, M.S. Sadak and H.M.S. El-Bassiouny, 2012. Drought stress mitigation by Foliar application of salicylic acid in two linseed varieties grown under newly reclaimed sandy soil. J. Applied Sci. Res., 8: 3503-3514.
17. Sadak, M.S., S.R. El-Lethy and M.G. Dawood, 2013. Physiological role of benzoic acid and salicylic acid on growth, yield, some biochemical and antioxidant aspects of soybean plant. World J. Agric. Sci., 9: 435-442.
18. Abd Elhamid, E.M., S.A. Orabi and M.S. Sadak, 2016. Physiological responses of grain soaking with Aspirin on two cultivars of wheat plant. Int. J. ChemTech Res., 9: 124-131.
19. Dawood, M.G., M.E.S. El-Awadi, M.S. Sadak and S.R. El-Lethy, 2019. Comparison between the physiological role of carrot root extract and β-carotene in inducing *Helianthus annuus* L. drought tolerance. Asian J. Biol. Sci., 12: 231-241.
20. Jackson, M.L., 1973. Soil Chemical Analysis. 1st Edn., Prentice Hall Ltd., New Delhi, India, Pages: 498.

21. Lichtenthaler, H.K. and C. Buschmann, 2001. Chlorophylls and Carotenoids: Measurement and Characterization by UV-VIS Spectroscopy. In: Current Protocols in Food Analytical Chemistry, Wrolstad, R.E., T.E. Acree, H. An, E.A. Decker and M.H. Penner *et al*. (Eds.). John Wiley and Sons, New York, USA., pp: F4.3.1-F4.3.8.
22. Prud'homme, M.P., B. Gonzalez, J.P. Billard and J. Boucaud, 1992. Carbohydrate content, fructan and sucrose enzyme activities in roots, stubble and leaves of ryegrass (*Lolium perenne* L.) as affected by source/sink modification after cutting. J. Plant Phys., 140: 282-291.
23. Larsen, P., A. Harbo, S. Klungsoyr and T. Aasheim, 1962. On the biogenesis of some indole compounds in *Acetobacter xylinum*. Physiol. Plant., 15: 552-565.
24. Danil, A.D. and C.M. George, 1972. Peach seed dormancy in relation to endogenous inhibitors and applied growth substances. J. Am. Soc. Hortic. Sci., 17: 621-624.
25. Beaudoin-Eagan, L.D. and T.A. Thorpe, 1985. Tyrosine and phenylalanine ammonia lyase activities during shoot initiation in tobacco callus cultures. Plant Physiol., 78: 438-441.
26. AOAC., 2016. Official Methods of Analysis of AOAC International. 20th Edn., Association of Official Analytical Chemists, Arlington, VA., USA., ISBN-13: 978-0935584875, Pages: 3172.
27. Nassar, M.A. and H.R. Hassan, 2002. Evaluation of advanced generations of early flowering and heavy branching/high yielding mutants of Egyptian lupine. II-Chemical features of mutants. J. Agric. Sci. Mansoura Univ., 27: 6745-6763.
28. Ordonez, A.A.L., J.D. Gomez, M.A. Vattuone and M.I. Lsla, 2006. Antioxidant activities of *Sechium edule* (Jacq.) Swartz extracts. Food Chem., 97: 452-458.
29. Nagata, M. and I. Yamashita, 1992. Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. J. Jpn. Soc. Food Sci. Technol., 39: 925-928.
30. Gyamfi, M.A., M. Yonamine and Y. Aniya, 1999. Free-radical scavenging action of medicinal herbs from Ghana: *Thonningia sanguinea* on experimentally-induced liver injuries. Gen. Pharmacol.: Vasc. Syst., 32: 661-667.
31. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., Iowa State University Press, Ames, Iowa, USA., ISBN-13: 9780813815602, Pages: 507.
32. Bosila, H., N. Toaima, H. Al Amier and A.E. El Ateeq, 2012. Effect of some amino acids, precursors and light conditions on callus growth and silymarin content of *Silybum marianum* L. Al-Azhar J. Agric Res., 12: 85-104.
33. El-Sherbeny, M.R. and J.A.T. da Silva, 2013. Foliar treatment with proline and tyrosine affect the growth and yield of beetroot and some pigments in beetroot leaves. J. Hortic. Res., 21: 95-99.
34. Wahba, H.E., H.M. Motawe and A.Y. Ibrahim, 2015. Growth and chemical composition of *Urtica pilulifera* L. plant as influenced by foliar application of some amino acids. J. Mater. Environ. Sci., 6: 499-506.
35. Zulqadar, S.A., M. Arshad, M. Naveed, A. Hussain, Q. Nazir and M. Rizwan, 2015. Response of okra (*Abelmoschus esculentus* L.) to soil and foliar application of L-methionine. Soil Environ., 34: 180-186.
36. Taylor, S.E., N. Terry and R.P. Huston, 1982. Limiting factors in photosynthesis: III. Effects of iron nutrition on the activities of three regulatory enzymes of photosynthetic carbon metabolism. Plant Physiol., 70: 1541-1543.
37. Abreu, M.E. and S. Munne-Bosch, 2008. Salicylic acid may be involved in the regulation of drought-induced leaf senescence in perennials: A case study in field-grown *Salvia officinalis* L. plants. Environ. Exp. Bot., 64: 105-112.
38. Abd El-Samad, H.M., M.A.K. Shaddad and N. Barakat, 2010. The role of amino acids in improvement in salt tolerance of crop plants. J. Stress Physiol. Biochem., 6: 25-37.
39. El-Awadi, M.E., Y.R. Abdel-Baky, M.S. Sadak, A.A.B.A. Amin and M.G. Dawood,2016 2016. Physiological response of *Lupinus termis* to trans-cinammic acid and benzoic acid treatments under sandy soil conditions. Res. J. Pharm. Biol. Chem. Sci., 7: 120-129.
40. Hend, M.F.S., W.R.A. Sakr, A.Z. Sabh and A.A. Ragab, 2007. Effect of some chemical and bio-fertilizers on peppermint plants grown in sandy soil: 2. Effect on essential oil production, chemical composition and anatomical features. Ann. Agric. Sci. Ain Shams Univ., 52: 465-484.
41. El-Din, K.M.G. and M.S.A. Abd El-Wahed, 2005. Effect of some amino acids on growth and essential oil content of chamomile plant. Int. J. Agric. Biol., 7: 376-380.
42. El Karamany, M.F., H.A.A. Omer, B.A. Bakry, G.S. Bakhoum and M.S. Sadak, 2018. Impact of tryptophan treatment on yield and chemical composition of Berseem green fodder. Biosci. Res., 15: 3692-3707.
43. Taiz, L. and E. Zeiger, 2006. Plant Physiology. 4th Edn., Sinauer Associates Inc., Sunderland, MA., USA., ISBN-10: 0-87893-856-7, Pages: 764.
44. El-Awadi, M.E., A.M. El-Bassiony, Z.F. Fawzy and M.A. El-Nemr, 2011. Response of snap bean (*Phaseolus vulgaris* L.) plants to nitrogen fertilizer and foliar application with methionine and tryptophan. Nat. Sci., 9: 87-94.
45. Shekari, G. and J. Javanmardi, 2017. Application of cysteine, methionine and amino acid containing fertilizers to replace urea: The effects on yield and quality of *Broccoli*. Adv. Crop Sci. Technol., Vol. 5, No. 3. 10.4172/2329-8863.1000283.
46. Heldt, H.W. and B. Piechulla, 2010. Plant Biochemistry. 4th Edn., Academic Press, New York, USA., ISBN-13: 9780123849878, Pages: 656.

47. Tucker, G.A., 1993. Introduction. In: Biochemistry of Fruit Ripening, Seymour, G.B., J.E. Taylor and G.A. Tucker (Eds.). Chapman and Hall, London UK., ISBN: 978-0-412-40830-4, pp: 1-15.
48. Koca, N. and S. Karaman, 2015. The effects of plant growth regulators and L-phenylalanine on phenolic compounds of sweet basil. Food Chem., 166: 515-521.
49. Kim, H.J., F. Chen, X. Wang and N.C. Rajapakse, 2006. Effect of methyl jasmonate on secondary metabolites of sweet basil (*Ocimum basilicum* L.). J. Agric. Food Chem., 54: 2327-2332.
50. Kovacik, J., I. Kron, M. Repcak and M. Backor, 2007. Effect of feeding precursors on phenylalanine ammonia-lyase activity and coumarin accumulation in leaves of *Matricaria chamomilla* L. Plant Growth Regul., 52: 9-15.
51. Hassanein, R.A., H.K.I. Khattab, H.M.S. El-Bassiouny and M.S. Sadak, 2005. Increasing the active constituents of sepals of roselle (*Hibiscus sabdariffa* L.) plant by applying gibberellic acid and benzyladenine. J. Applied Sci. Res., 1: 137-146.
52. Khan, W., B. Prithiviraj and D.L. Smith, 2003. Photosynthetic responses of corn and soybean to foliar application of salicylates. J. Plant Physiol., 160: 485-492.
53. Martel, A.B. and M.M. Qaderi, 2016. Does salicylic acid mitigate the adverse effects of temperature and ultraviolet-B radiation on pea (*Pisum sativum*) plants? Environ. Exp. Bot., 122: 39-48.
54. Mervat, S.S. and M.A.E. Ebtihal, 2013. Physiological response of flax cultivars to the effect of salinity and salicylic acid. J. Applied Sci. Res., 9: 3573-3581.
55. Bukhsh, M.A.A.H.A., A.U. Malik, M. Ishaque and S.H. Sadiq, 2009. Performance of sunflower in response to exogenously applied salicylic acid under varying irrigation regimes. J. Anim. Plant Sci., 19: 130-134.
56. Raskin, I., 1992. Role of salicylic acid in plants. Ann. Rev. Plant Physiol. Plant Mol. Biol., 43: 439-463.
57. Baranska, M., W. Schutze and H. Schulz, 2006. Determination of lycopene and β-carotene content in tomato fruits and related products: Comparison of FT-Raman, ATR-IR and NIR spectroscopy. Anal. Chem., 78: 8456-8461.
58. Zhang, L.X., R.V. Cooney and J.S. Bertram, 1991. Carotenoids enhance gap junctional communication and inhibit lipid peroxidation in C3H/10T1/2 cells: Relationship to their cancer chemopreventive action. Carcinogenesis, 12: 2109-2114.
59. Astorg, P., S. Gradelet, R. Berges and M. Suschetet, 1997. Dietary lycopene decreases the initiation of liver preneoplastic foci by diethylnitrosamine in the rat. Nutr. Cancer, 29: 60-68.
60. Abdel-Rahim, E.A., M.A. Shalla, S.H. Ahmed and M.M. Farag, 2000. Effects of some plant growth regulators on datura seeds oil. J. Agric. Sci. Mansoura Univ., 25: 8249-8259.