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Effect of Planting Dates, Compost and Foliar Spraying with some Amino Acids on Growth, Chemical Composition of feverfew (*Tanacetum parthenium* L.) Plants

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ABSTRACT

Feverfew(*Tanacetum parthenium* L.)is a valuable medicinal plant from *Asteraceae* family with various pharmacological and therapeutic properties. So, two pot trials were conducted at the Experimental Farm of Medical and Aromatic Plants, Fac. of Agric., Mansoura Univ., Egypt during winter seasons of 2018 and 2019 to study the response of feverfew plants to different planting dates(1st, 15th and 30th December),addition of compost at various rates (0, 22, 33 and 44 g / pot) and foliar spraying with amino acids *i.e.,* glycine and tryptophan(1.0 mgl^{-1})under sandy soil condition. The experimental design was a split-split-plot with three replicates. Vegetative growth criteria *i.e.,* fresh and dry weights, plant height and No. of branches, chemical traits *i.e.* N, P, K, chlorophyll and carotene content as well as essential oil percentage were determined. The findings showed that the feverfew plants transplanted on December 15th possessed the highest values of all aforementioned traits as compared to the other transplanting dates. Regarding compost effect, the highest values were owing to the addition of 44g compost pot^{-1} followed by 33g compost pot^{-1} then 22 g compost pot^{-1} and lately control treatment(without compost addition).Foliar spaying with both glycine and tryptophan caused a pronounced increase in all aforementioned traits as compared to plants sprayed with tap water(control treatment).Furthermore, the values with glycine were higher than that with tryptophan. Generally, the highest values of all aforementioned traits were recorded when feverfew plants were transplanted on 15th Dec in pots contained 44g compost with foliar application of glycine at rate of 1.0 mgl^{-1}.

***Keywords**: Feverfew plants, Planting dates, Compost, Amino acids, Glycine and Tryptophan.*

INTRODUCTION

Feverfew (*Tanacetum parthenium* L.) plant has a long history of use in traditional and folk medicine, especially among Greek and early European herbalists. The plant has multiple pharmacologic properties, such as anticancer, anti-inflammatory, cardiotonic, antispasmodic, an emmenagogue, and as an enema for worms. The plant is widely cultivated to large regions of the world and its importance as a medicinal plant is growing substantially with increasing and stronger reports in support of its multifarious therapeutic uses (Pourianezhad *et al.*, 2016).

Planting date has important effect on plant development and effect on active substance of medicinal plants (Ghani *et al.,* 2011). Earlier sowing increased the length of time that plants can take advantage of favorable growing conditions (Soleymani and Shahrajabian, 2012). Very limited information is available about effect of planting dates on feverfew plants. Mohammad *et al.*, (2010) mentioned that planting date had significant effects on all of the agro-morphological characteristics of German chamomile. The highest values for them were obtained from early date of planting whereas values decreased with later planting dates. Al-Dalain *et al.* (2012) showed that early planting significantly increased the fruit yield of fennel combined with higher number of branches per plant, number of umbrellas per plant, number of fruits per plant and plant height. Kakaraparthi *et al.* (2013) reported that the total alkaloid content of the root of *Withania somnifera* plants increased with the advancement in early sowing date and decreased in late sowings date. Wafaa *et al.* (2017) showed that the significantly maximum increments in oil yields were obtained when fennel plants were sown in the early sowing date (15th October).

Plant nutrition is one of the most important factors that affect plant production (Massoud *et al*., 2016). In terms of environmental impact and qualitative and quantitative yield of medicinal plants, consumption management of organic fertilizers is very important, especially in arid and semiarid areas such as Egypt (Mirshekari and Forouzandeh, 2015). The usage of organic fertilizers such as compost in agricultural purposes positively affects the soil physical and chemical properties, thus enhances plant growth, crop yield and crop quality (Sanni and Okeowo, 2016). Sandy soils with low colloidal content are suffering from lack of water and nutrient supply potentials, high infiltration rate, high evaporation, low organic matter content and excessive deep percolation, reduction in its products as well (Głąb *et al.*, 2018). Appropriate soil conditioners such as compost could be used to tackle these problems through improving the retention capacities and allow plants to get their water and nutrient requirements easily. Compost plays an important role in improving the chemical and physical characteristics of degraded soils such as sandy soil and supplying macro and micronutrients (Kheir and Kamara, 2019).

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Amino acids are particularly important for cell growth stimulation. They act as buffers which help to maintain favorable pH the value within the plant cell since they contain both acid and basic groups. They remove ammonia from the cell, so they protect plants from ammonia toxicity. Amino acids have a function in the biosynthesis of other organic compounds i.e., pigments, vitamins, alkaloids, enzymes, terpenoids, coenzymes, purine and pyrimidine bases. Amino acids have the greatest importance in plant nutrition for obtaining of higher yields and quality and shortening of the productive cycle with better dry material. It gave more abundant and more uniform flowering. Previous studies have proved that amino acids can directly or indirectly influence the physiological activities of the plant. As well as amino acids help in improving the microflora of the soil thereby facilitating the assimilation of nutrients (Hadi *et al.,* 2011). Armin and Miri (2014) stated that glycine betaine is an amino component that accumulates in many plant species under drought stress. Increasing in glycine betaine in this situation can increase plant drought resistance. Glycine acid plays an important role in formation of vegetative growth and chlorophyll. It also has a chelating effect on some micronutrients such as Fe, Zn, Mn, and Cu through making absorption and transportation eases for the plant (Ghasemi *et al*., 2013). Glycine is a fundamental metabolite in the process of chlorophyll synthesis (Wahba *et al.,* (2015). Tryptophan helps the formation of indole acetic acid (IAA) and plays an important role in early growth. Whereas, Phillips (1971) suggested several alternatives role of IAA synthesis in plants, all starting from tryptophan, thus, when tryptophan is supplied to most plant tissues, IAA was formed. It is also synthesized by hydrolysis of proteins of dead cells (Patten and Glick, 1996), and is converted into indole acetic acid by the activity of plant growth-promoting rhizobacteria (Sasirekha *et al.* 2012). L-tryptophan, the precursor of IAA is naturally present in root exudates of plants (Villareal *et al.,* 2012).

Up to date, few papers have focused on the combined influence of planting dates, compost addition and spraying amino acids on feverfew plants. So, the aim of this investigation is to improve the growth performance and essential oil percentage of feverfew plants grown on sandy soil at different planting dates by applying different levels of compost with foliar application of different amino acids and define the treatment which improves growth and essential oil production of feverfew plants because of its pharmaceutical importance.

MATERIALS AND METHODS

Two pot trials were conducted at the Experimental Farm of Medical and Aromatic Plants, Fac. of Agric., Mansoura Univ., Egypt during winter seasons of 2018 and 2019 to study the response of feverfew plants (*Tanacetum parthenium* L.) to different planting dates, addition of compost at various rates and foliar spraying with amino acids under sandy soil condition. Surface soil samples (0-30 cm) were collected from a private farm in Qalapshoo Village, Belqas District, Dakahlia Governorate, Egypt to represent sandy soil. The obtained soil samples were analyzed before planting as a routine work according to Dewis and Fertias (1970) as shown in Table A.

A. Some properties of the experimental soil.

Soil characteristics		Values
Mechanical analysis (%)	C. Sand	23.0
	F. Sand	63.5
	Silt	2.7
	Clay	10.8
Soil texture		Sandy
Hydro physical analyses (%)	Field capacity	15.0
	Saturation %	30.0
Chemical analyses	$CaCO_3$ (%)	1.10
	Organic matter (%)	0.25
	pH	7.90
	EC (dSm^{-1})	0.75
Available element mg kg^{-1}	Nitrogen	37.4
	Phosphorus	4.70
	Potassium	166.0

Compost (plant residues) and the amino acids were obtained from Agricultural Research Center, Egypt and the chemical analysis of the compost is presented in Table B.

B. Chemical analysis of compost used.

Characteristics		Values
Weight of m^3 kg^{-1}		325.0
EC (1:10) (dSm^{-1})		3.71
pH (1:10)		6.15
OM %		35.1
Organic carbon %		20.0
C/N ratio		13.3
Nutrients (%)	Nitrogen	1.50
	Phosphorus	0.48
	Potassium	0.85

Experimental Design:

Thirty-six treatments, which were the simple possible combination between three planting dates (1st, 15th and 30th December), four compost levels (0, 22, 33 and 44 g per pot) and three foliar applications (tap water, glycine and tryptophan at rate of 1.0 mgl^{-1}) were arranged in a split-split plot design. The planting dates represented the main plots and compost treatments were devoted in sub-plots while the foliar applications were allocated in the sub-sub-plots. Each treatment was replicated three times. Thus, the total number of pots used for each season was 108 pots. To carry out the experiment, plastic pots (30 cm diameter and 40 cm depth) were filled by air dry soils equaled to 15 kg oven dry soil. Two uniform feverfew seedlings (75 days old) were transplanted carefully on above-mentioned dates in both seasons of the study and were thinned to one plant per pot after 30 days from transplanting. The top 15 cm of the pot soil was mixed with compost at above mentioned rates at 15 days before transplanting. The feverfew plants were sprayed with amino acids *i.e.*, glycine and tryptophan at rate of 1.0 mgl^{-1} in addition to tap water as control treatment by hand sprayer until saturation point three times, after 30 days from transplanting, and repeated each 7 days interval. Mineral fertilizer (20N: 20P: 20K) were obtained from El- Delta Company for Fertilizers and Chemical Industries (ASMEDA), Egypt. The amount of chemical fertilizer was divided to ten equal doses (each dose was 2g pot^{-1}). The first dose was added after 20 days from transplanting and repeated each two weeks interval. Irrigation was carried out every 2 days to reach the soil field capacity by weight.

Data recorded:

Picking of inflorescences stared on May 15th and continued till June 15th with 7days intervals. At 30th June (after the last pick), vegetative growth parameters as well as chemical constituents in leaves were determined. At the end of the experiment in each season (15 days after the last pick) plant of each pot was cut 5 cm above the soil level and the average herb fresh and dry weights (g), shoot length (cm) and number of branches plant^{-1} were determined. Total –N was determined using Micro kjeldahl apparatus as described by (Jones *et al*.,1991). Total phosphorus was determined spectrophotometrically as described by (Peters *et al*., 2003). Total potassium was estimated by using flame photometer according to the modified method of (Peters *et al*., 2003). Chlorophyll content was estimated according to (Sadasivam and Manickam., 1996). Carotene content of feverfew leaves was determined spectrophotometrically by the procedure postulated by Ranganna (1997). Essential oil (%) was determined in the dried samples (100 g) in both seasons by subjecting inflorescences to hydro distillation in Clevenger apparatus according to the method described by British Pharmacopoeia (2000). The Essential oil percentage was calculated as follows:

$$\textbf{Oil percentage} = \frac{\textbf{Volume of oil in gradated tube (ml)}}{\textbf{Dry weight of inflorescences}} \times 100$$

Statistical analysis:

Data were undergone to the analysis of variance (ANOVA) using the Costate v. 6.303 (2004) program. Means were compared by the least significance difference (LSD) test at the 0.05 prospect level according to the procedure as mentioned by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Results

A- Vegetative Growth Criteria:

1.Herb fresh and dry weights (g plant^{-1}).

The transplanting dates effect on fresh and dry weights of feverfew shoots are showed in Figs. (1) and (2). The values significantly affected due to different transplanting dates, where the feverfew plants transplanted on December 15th possessed the highest values of herb fresh and dry weights as compared to the other transplanting dates in both studied seasons. Generally, the transplanting dates sequence from top to less were December 15th > December 1st > December 30th.

Figs. (1) and (2) indicate that mixing compost with the studied sandy soil at period of 15 days before transplanting at rates of 22.0, 33.0 and 44.0 g pot^{-1} significantly increased fresh and dry weights of feverfew shoots as compared to untreated plants (without compost) during both seasons of experimentation, where the highest values were owing to the addition of 44 g compost pot^{-1} followed by 33 g compost pot^{-1} then 22 g compost pot^{-1} and lately control treatment (without compost addition), such effect was the same during the two seasons of the experiment.

The same Figs indicate that foliar spaying with amino acids such as glycine and tryptophan caused a pronounced increase in the fresh and dry weights of feverfew shoots as compared to plants sprayed with tap water (control treatment) during the both season of the experimentation. Furthermore, the values of fresh and dry weights of feverfew plants sprayed with glycine were higher than that sprayed with tryptophan.

Regarding the interaction effect among the investigated treatments, it was obvious from Table 1 that feverfew plants recorded the highest values of fresh and dry weights (g plant^{-1}) when they were transplanted on 15th Dec in pots contained 44g compost with foliar application of glycine at rate of 1 mgl^{-1}. While, the lowest values were recorded with feverfew plants transplanted on 30th Dec without both compost and amino acids.

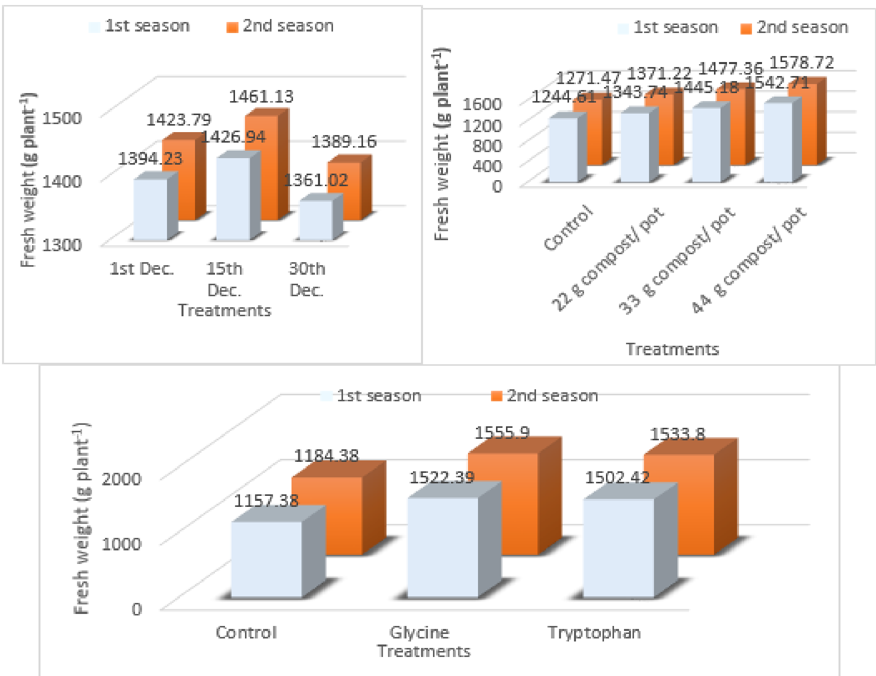

Fig. 1. Effect of planting dates, compost additions and foliar spraying with amino acids on fresh weights of feverfew shoot at 2018 and 2019 seasons.

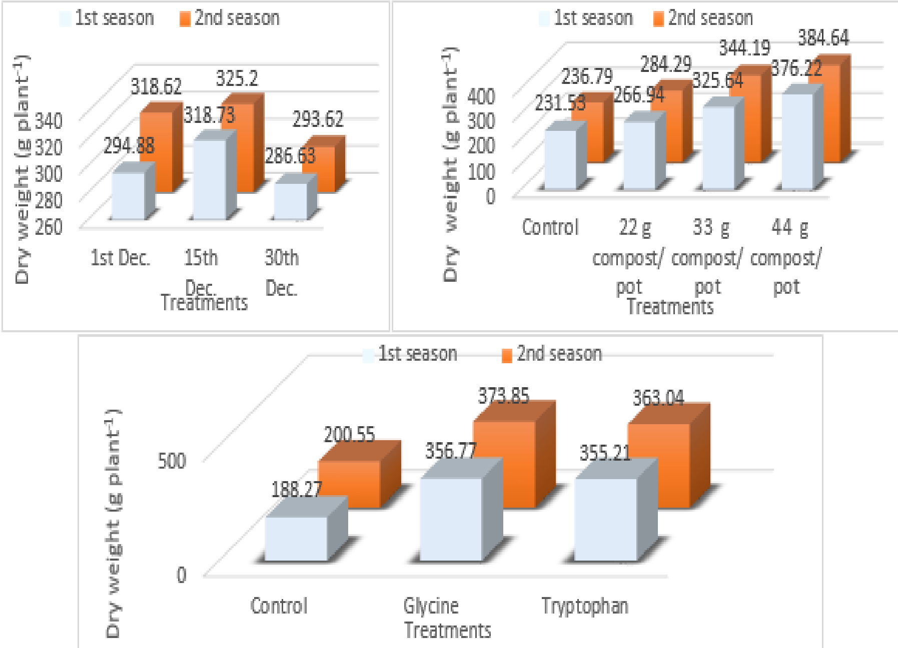

Fig. 2. Effect of planting dates, compost additions and foliar spraying with amino acids on dry weights of feverfew shoot at 2018 and 2019 seasons.

2. Plant height (cm) and number of branches plant^{-1}.

Figs. (3) and (4) show the effect of transplanting dates on plant height (cm) and number of branches plant^{-1} of feverfew plants. The December 15th was the superior date followed by 1st and December 30th, respectively, such effect was the same during the two seasons of the experiment.

Concerning the individual effect of compost additions Figs. (3) and (4) illustrate that addition of compost at rate of 44.0 (g pot^{-1}) in pots contained sandy soil was superior treatment for plant height (cm) and number of branches plant^{-1} of feverfew plants as compared to other compost levels, where the compost levels sequence from top to less were 44 > 33 > 22 g compost pot^{-1}> control treatment..

With regard to the effect of glycine and tryptophan, the same Figs show that feverfew plants sprayed with glycine had the highest values of all aforementioned traits followed by tryptophan, while the lowest values were recorded with control (sprayed with tap water).

Going along with combination treatments among planting dates, compost levels and amino acids, it was obvious from Table (1) that combination of 15th Dec as transplanting date + 44.0g compost pot^{-1} + glycine at rate of 1.0 mg l^{-1} resulted in significant increase in the plant height (cm) and number of branches plant^{-1} of feverfew plants over all other combined treatments. While, the lowest values were recorded with plants transplanted on 30th Dec without compost and amino acids.

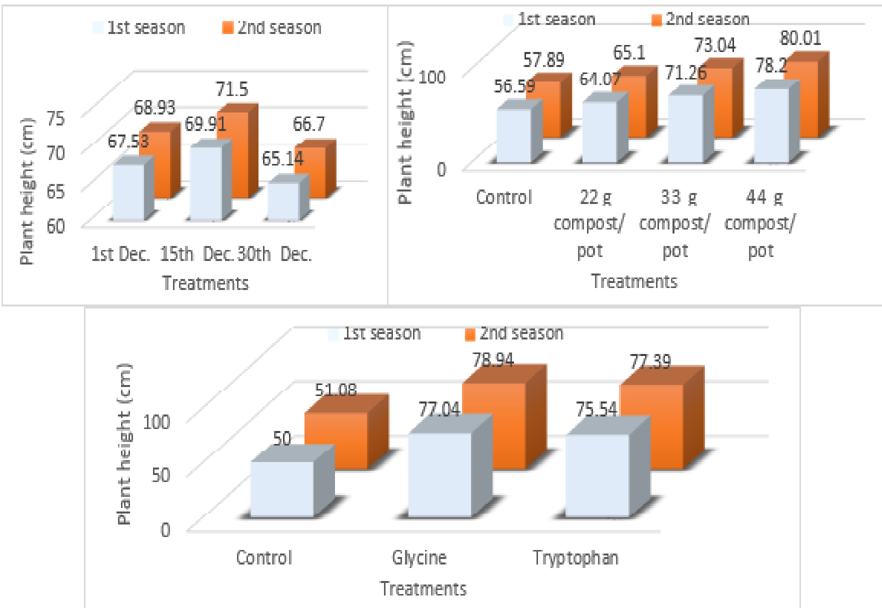

Fig. 3. Effect of planting dates, compost additions and foliar spraying with amino acids on plant height of feverfew shoot at 2018 and 2019 seasons.

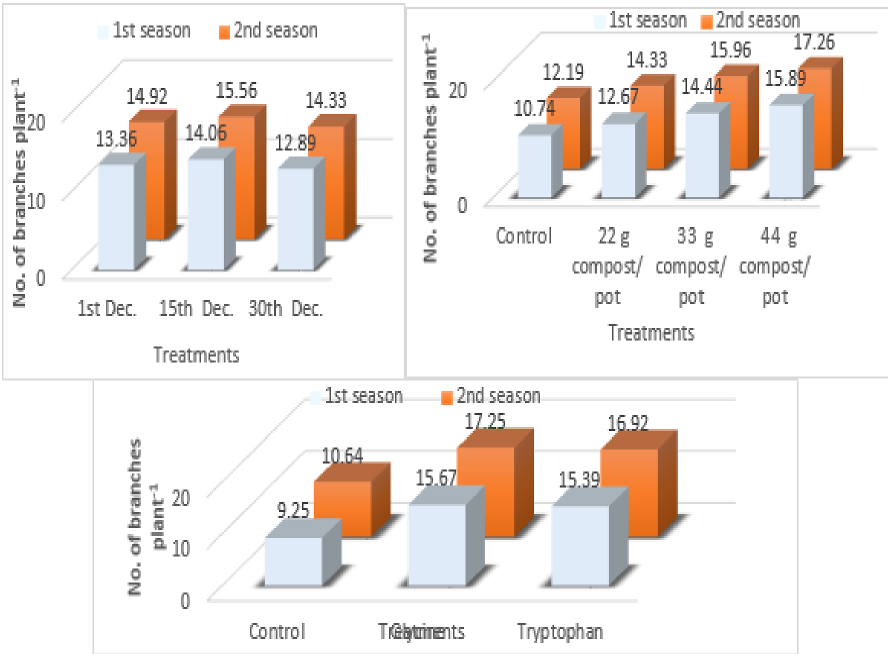

Fig. 4. Effect of planting dates, compost additions and foliar spraying with amino acids on No. of branches of feverfew shoot at 2018 and 2019 seasons.

Table 1. Interaction effects among planting dates, compost and foliar application of amino acids on vegetative growth criteria of feverfew shoot during 2018 and 2019 seasons.

Treatments	**Characters**		**Weights g/plant**				**Plant height (cm)**		**No. of branches plant-1**	
			Fresh		**Dry**					
			2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
1st Dec.	Without compost	Control	1073.01	1102.84	147.76	149.48	43.83	44.70	7.00	8.33
		Glycine	1341.67	1370.20	279.88	286.11	63.90	65.47	12.00	14.33
		Tryptophan	1318.92	1349.69	268.33	273.82	62.00	63.07	12.67	14.00
	22 g compost pot-1	Control	1126.14	1153.51	170.75	174.73	48.00	48.80	8.33	10.00
		Glycine	1463.68	1487.39	237.14	343.77	72.90	74.50	15.00	16.33
		Tryptophan	1440.04	1467.40	326.31	335.86	71.50	72.71	14.33	16.33
	33 g compost pot-1	Control	1184.98	1205.97	202.15	307.41	51.97	53.36	10.33	11.67
		Glycine	1587.34	1620.03	392.64	402.69	81.43	83.71	16.67	18.33
		Tryptophan	1567.42	1590.71	383.36	392.31	80.27	82.68	16.33	18.00
	44 g compost pot-1	Control	1243.97	1280.04	232.74	237.54	56.30	57.48	11.33	12.67
		Glycine	1700.95	1739.77	453.09	464.88	89.70	91.15	18.33	19.67
		Tryptophan	1682.68	1718.00	444.45	454.78	88.53	91.42	18.00	19.33
15th Dec.	Without compost	Control	1091.42	1113.03	154.98	158.57	45.20	46.12	7.33	9.00
		Glycine	1380.14	1414.83	299.20	307.37	66.93	68.39	13.67	15.33
		Tryptophan	1360.72	1387.68	289.09	295.15	65.33	67.15	13.33	14.67
	22 g compost pot-1	Control	1145.84	1173.56	179.41	182.91	49.27	50.14	9.00	11.00
		Glycine	1503.21	1542.39	354.80	360.94	75.87	77.80	15.67	17.33
		Tryptophan	1482.80	1518.86	345.37	351.74	74.07	75.67	15.33	17.00
	33 g compost pot-1	Control	1204.99	1236.49	213.24	218.40	53.47	54.58	10.67	12.00
		Glycine	1623.92	1663.28	410.08	419.88	84.43	86.97	17.33	18.67
		Tryptophan	1605.71	1646.85	400.64	406.17	83.03	84.45	17.00	18.33
	44 g compost pot-1	Control	1263.69	1295.04	241.68	244.72	57.53	59.13	11.67	13.00
		Glycine	1739.24	1777.74	473.80	484.35	92.63	94.15	19.00	20.33
		Tryptophan	1721.59	1763.80	462.52	472.26	91.20	93.45	18.67	20.00
30th Dec.	Without compost	Control	1056.01	1078.83	137.64	140.92	42.40	43.47	6.33	7.00
		Glycine	1299.45	1322.10	257.82	262.91	60.73	62.67	12.33	13.67
		Tryptophan	1280.12	1304.00	249.09	256.81	58.97	59.99	12.00	13.33
	22 g compost pot-1	Control	1109.29	1126.72	163.18	167.37	46.60	47.49	8.00	9.33
		Glycine	1420.55	1449.30	316.78	325.62	70.03	71.33	14.33	16.00
		Tryptophan	1402.15	1421.88	308.72	315.70	68.40	70.58	14.00	15.67
	33 g compost pot-1	Control	1164.66	1197.64	191.82	195.79	50.53	51.64	10.00	11.33
		Glycine	1545.02	1577.25	373.27	383.17	78.83	80.11	16.00	18.00
		Tryptophan	1522.64	1558.02	363.53	371.87	77.37	79.88	15.67	17.33
	44 g compost pot-1	Control	1224.59	1248.92	223.85	228.75	54.93	56.08	11.00	12.33
		Glycine	1663.49	1706.53	432.71	444.55	87.07	89.55	17.67	19.00
		Tryptophan	1644.22	1678.69	421.11	429.97	85.87	87.64	17.33	19.00
LSD at 5%			9.24	29.83	47.61	47.35	0.49	0.53	1.11	1.17

B- Chemical Constituents:

1- Nitrogen, phosphorus and potassium.

Figs. (5, 6 and 7) reveal that N, P and K percentages in leaves of feverfew plants were significantly affected by different transplanting dates, where the highest values were recorded when feverfew plants were transplanted on 15th followed by 1st and 30th of December, respectively. This trend was found in both studied seasons.

Also, the values of N, P and K % in leaves of feverfew plants significantly increased as the level of compost increased, where the highest values of all these nutrients were realized for the feverfew plants fertilized with 44.0 g compost pot^{-1} as compared to other treatments. The plants fertilized with 33.0 g compost pot^{-1} come in the second order, then the plants fertilized with 22.0 g compost pot^{-1}, while the feverfew plants unfertilized with compost before planting recorded the lowest values of N, P and K nutrients (%).

Regarding individual effect of some foliar applications *i.e.*, tap water (control), glycine and tryptophan acids on the values of N, P and K % in leaves of feverfew plants, the same Figs show that foliar application of amino acids *i.e.*, glycine and tryptophan gave more N, P and K % in leaves of feverfew plants as compared to tap water treatment. On the other hand, the highest values of N, P and K % in leaves of feverfew plants were obtained when plants received glycine followed by that supplied with tryptophan.

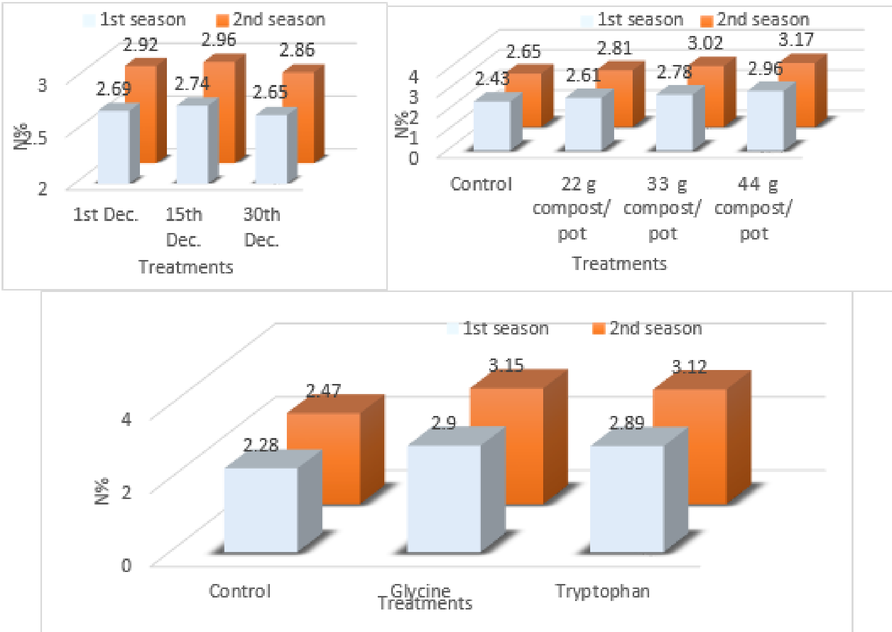

Fig. 5. Effect of planting dates, compost additions and foliar spraying with amino acids on N (%) in leaves of feverfew at 2018 and 2019 seasons.

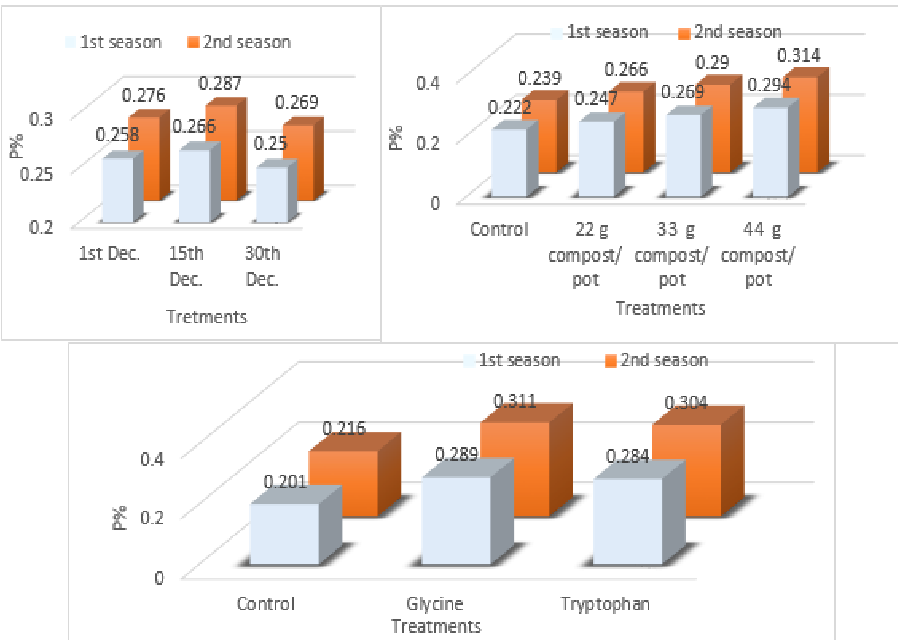

Fig. 6. Effect of planting dates, compost additions and foliar spraying with amino acids on P (%) in leaves of feverfew during 2018 and 2019 seasons.

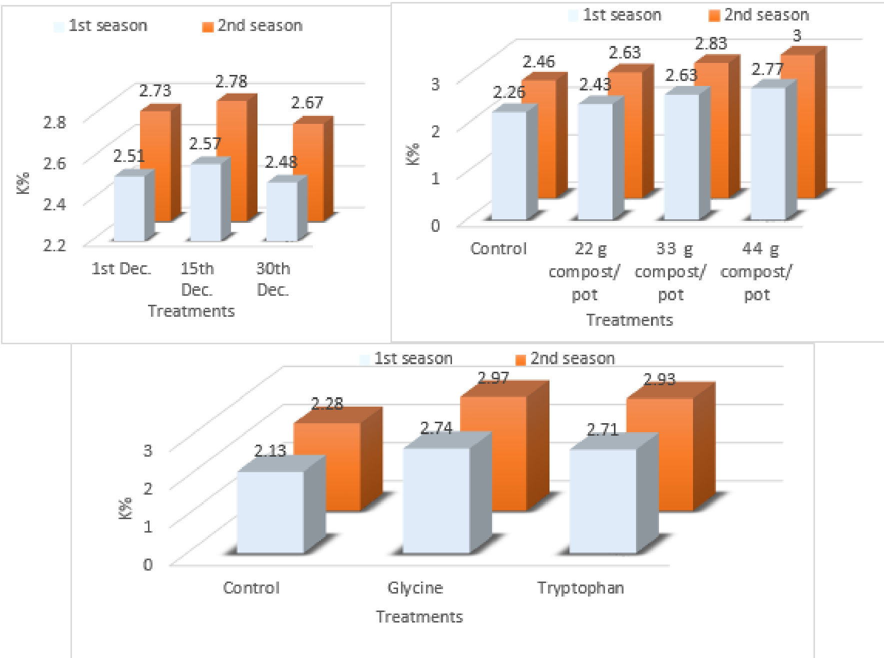

Fig. 7. Effect of planting dates, compost additions and foliar spraying with amino acids on K (%) in leaves of feverfew at 2018 and 2019 seasons.

The comparison among the various combined treatments of planting dates, compost levels and amino acids as shown in Table 2 has been reflected significant differences between the values of N, P and K (%) in the leaves of feverfew during both seasons of the experimentation.

Table 2. Interaction effects among planting dates, compost and foliar application of amino acids on N, P and K **percentages in leaves of feverfew plants during 2018 and 2019 seasons.**

Treatments	Characters		N (%) 2018	N (%) 2019	P (%) 2018	P (%) 2019	K (%) 2018	K (%) 2019
1st Dec.	Without compost	Control	2.11	2.30	0.179	0.191	1.93	2.11
		Glycine	2.61	2.82	0.246	0.263	2.43	2.63
		Tryptophan	2.57	2.87	0.244	0.266	2.41	2.65
	22 g compost pot^{-1}	Control	2.22	2.38	0.195	0.204	2.04	2.19
		Glycine	2.81	2.99	0.275	0.291	2.64	2.80
		Tryptophan	2.77	3.02	0.271	0.287	2.60	2.83
	33 g compost pot^{-1}	Control	2.36	2.55	0.206	0.220	2.16	2.34
		Glycine	3.03	3.36	0.302	0.331	2.82	3.11
		Tryptophan	2.98	3.21	0.297	0.317	2.80	3.04
	44 g compost pot^{-1}	Control	2.43	2.67	0.221	0.238	2.28	2.48
		Glycine	3.19	3.41	0.332	0.355	3.04	3.25
		Tryptophan	3.17	3.46	0.328	0.351	3.01	3.29
15th Dec.	Without compost	Control	2.16	2.32	0.185	0.196	1.98	2.13
		Glycine	2.67	2.97	0.256	0.278	2.51	2.76
		Tryptophan	2.63	2.82	0.251	0.265	2.48	2.65
	22 g compost pot^{-1}	Control	2.27	2.41	0.201	0.241	2.09	2.22
		Glycine	2.88	3.14	0.285	0.307	2.71	3.01
		Tryptophan	2.85	3.08	0.278	0.297	2.68	2.89
	33 g compost pot^{-1}	Control	2.38	2.64	0.213	0.231	2.19	2.42
		Glycine	3.07	3.30	0.313	0.336	2.90	3.15
		Tryptophan	3.05	3.31	0.307	0.332	2.87	3.13
	44 g compost pot^{-1}	Control	2.47	2.61	0.227	0.240	2.31	2.48
		Glycine	3.26	3.49	0.342	0.364	3.11	3.33
		Tryptophan	3.23	3.44	0.337	0.354	3.06	3.24
30th Dec.	Without compost	Control	2.05	2.23	0.171	0.184	1.88	2.05
		Glycine	2.53	2.73	0.237	0.254	2.37	2.57
		Tryptophan	2.52	2.79	0.233	0.252	2.34	2.57
	22 g compost pot^{-1}	Control	2.20	2.38	0.190	0.204	2.01	2.18
		Glycine	2.73	2.99	0.266	0.287	2.57	2.80
		Tryptophan	2.71	2.90	0.261	0.277	2.55	2.73
	33 g compost pot^{-1}	Control	2.32	2.47	0.203	0.212	2.39	2.25
		Glycine	2.94	3.20	0.294	0.318	2.77	3.03
		Tryptophan	2.91	3.14	0.289	0.310	2.74	2.97
	44 g compost pot^{-1}	Control	2.42	2.68	0.217	0.236	2.24	2.47
		Glycine	3.14	3.39	0.322	0.345	2.99	3.24
		Tryptophan	3.35	3.36	0.318	0.344	2.94	3.20
LSD at 5%			0.11	0.05	0.006	0.015	0.12	0.05

The maximum N (3.26 and 3.49 % for 1st and 2nd seasons, respectively), P (0.342 and 0.364 % for 1st and 2ndseasons, respectively) and K (3.11 and 3.33 % for 1st and 2nd seasons, respectively) were recorded with the combination of 15th Dec as planting date × addition of 44g compost pot-1× foliar application of glycine. While the lowest values of N (2.05 and 2.23 % for 1st and 2nd seasons, respectively), P (0.171 and 0.184 % for 1st and 2ndseasons, respectively), and K (1.88 and 2.05 % for 1st and 2nd seasons, respectively) were realized under the combination of 30th Dec as planting date × without compost × foliar application of tap water

2-Photosynthetic pigments.

Figs from 8 to 11 elucidate that photosynthetic pigments *i.e.* chlorophyll a, b and total chlorophyll as well as carotene (mg g^{-1} F.W) of feverfew plants were significantly affected by different planting dates, where the highest values of all aforementioned traits were realized when feverfew plants were transplanted on December 15th as compared to other planting dates followed by December 1st, while the lowest values were realized when feverfew plants were transplanted on December 30th.This trend was found in both studied seasons.

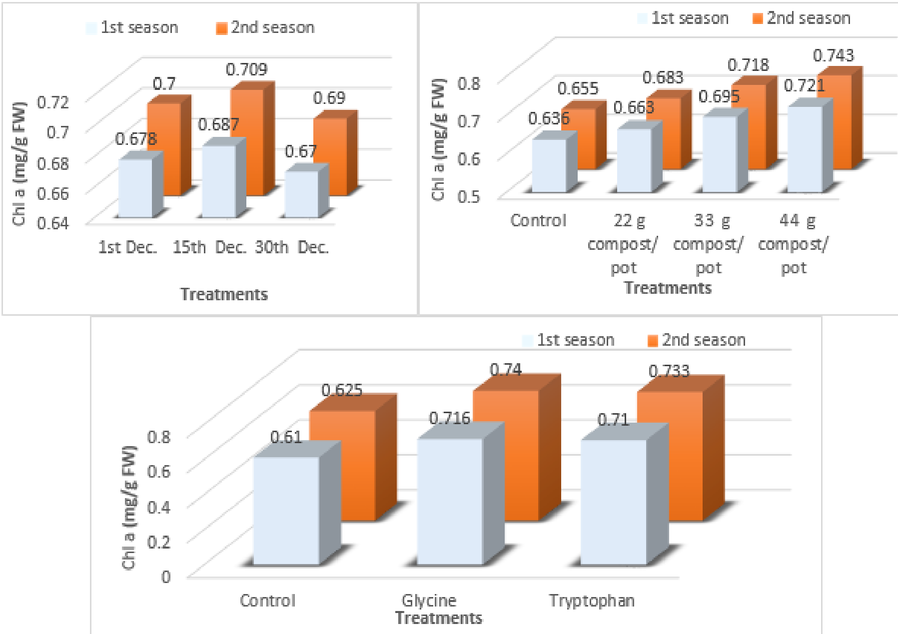

Fig. 8. Effect of planting dates, compost additions and foliar spraying with amino acids on chlorophyll a (mg/g FW) in leaves of feverfew at 2018 and 2019 seasons.

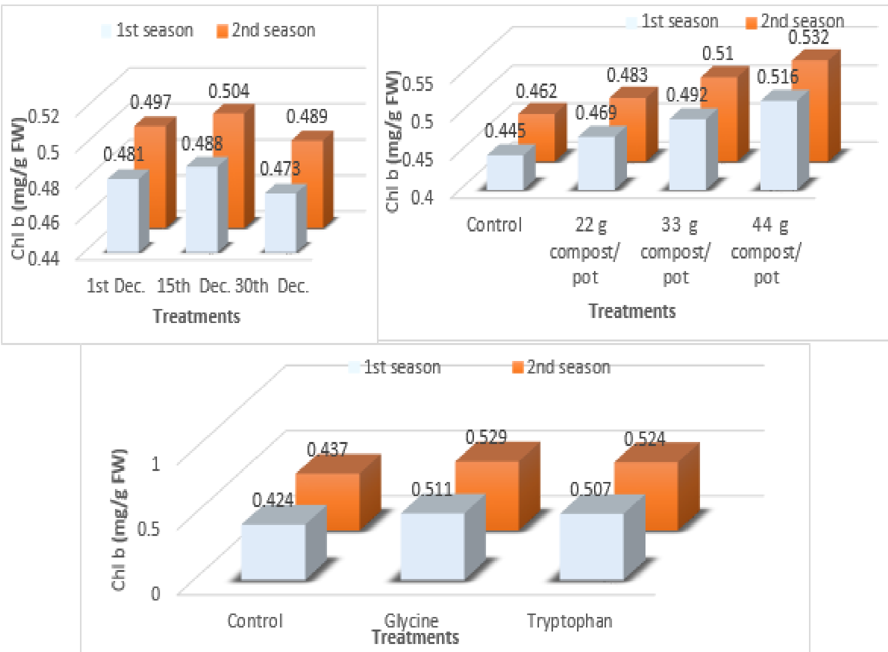

Fig. 9. Effect of planting dates, compost additions and foliar spraying with amino acids on chlorophyll b (mg/g FW) in leaves of feverfew at 2018 and 2019 seasons.

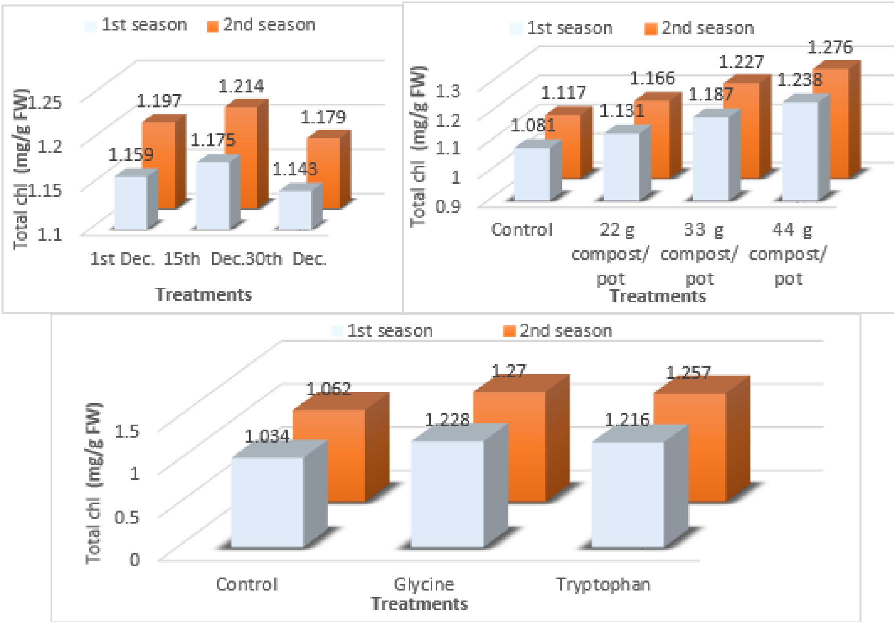

Fig. 10. Effect of planting dates, compost additions and foliar spraying with amino acids on total chlorophyll (mg/g FW) in leaves of feverfew at 2018 and 2019 seasons.

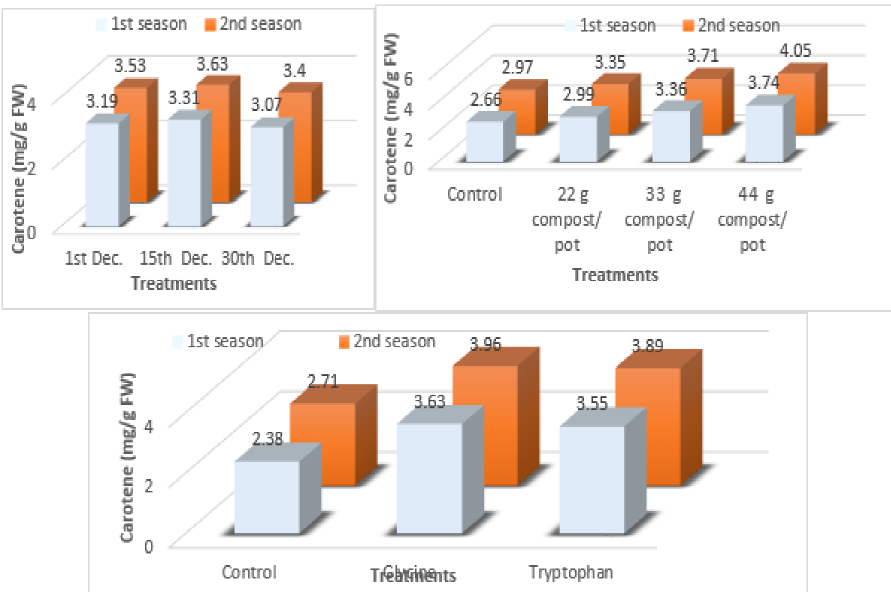

Fig. 11. Effect of planting dates, compost additions and foliar spraying with amino acids on carotene (mg/g FW) in leaves of feverfew at 2018 and 2019 seasons.

Regarding the compost effect, the same Figs illustrate that the trend of photosynthetic pigments *i.e.*, chlorophyll a, b and total chlorophyll as well as carotene (mg g^{-1} F.W) of feverfew plants looks just like nutrients trend, where the values of all photosynthetic pigments increased as the level of compost increased. On other words, the compost levels sequence from top to less were 44 > 33 > 22 g compost $^{pot-1}$ > control treatment.

Data in the same Figs indicate that foliar spaying with amino acids such as glycine and tryptophan caused a pronounced increase in all studied photosynthetic pigments *i.e.* chlorophyll a, b, total chlorophyll and carotene (mg g^{-1} F.W) of feverfew plants as compared to plants sprayed with tap water (control treatment) during the both season of the experimentation. On the other hand, the values of all aforementioned traits of feverfew plants sprayed with glycine acid were highest as compared to the values of plants sprayed with tryptophan acid.

Concerning the interaction effect among the investigated treatments, it was obvious from Table 3 that feverfew plants recorded the highest values of photosynthetic pigments *i.e.*, chlorophyll a, b, total chlorophyll and carotene (mg g^{-1} F.W) when they were transplanted on 15th Dec in pots contained 44g compost with foliar application of glycine at rate of 1.0 mgl^{-1}. While, the lowest values of photosynthetic pigments *i.e.*, chlorophyll a, b, total chlorophyll and carotene (mg g^{-1} F.W) were recorded with feverfew plants transplanted on 30th Dec without both compost and amino acids.

Table 3. Interaction effects among planting dates, compost and foliar application of amino acids on photosynthetic pigments of feverfew plants at 2018 and 2019 seasons.

Treatments		Characters	Chlorophyll a		Chlorophyll b		Total chlorophyll		Carotene	
			(mg/g FW)							
			2018	2019	2018	2019	2018	2019	2018	2019
1st Dec.	Without compost	Control	0.586	0.598	0.405	0.421	0.991	1.019	2.10	2.34
		Glycine	0.663	0.684	0.469	0.483	1.132	1.167	2.97	3.31
		Tryptophan	0.658	0.683	0.463	0.480	1.121	1.163	2.91	3.22
	22 g compost pot^{-1}	Control	0.599	0.611	0.415	0.423	1.014	1.035	2.30	2.80
		Glycine	0.698	0.727	0.497	0.516	1.196	1.243	3.34	3.76
		Tryptophan	0.692	0.712	0.495	0.507	1.187	1.219	3.30	3.66
	33 g compost pot^{-1}	Control	0.619	0.644	0.432	0.451	1.052	1.095	2.48	2.83
		Glycine	0.733	0.755	0.525	0.541	1.259	1.296	3.87	4.19
		Tryptophan	0.729	0.758	0.519	0.540	1.247	1.297	3.76	4.11
	44 g compost pot^{-1}	Control	0.636	0.647	0.445	0.455	1.081	1.102	2.67	2.99
		Glycine	0.768	0.798	0.555	0.577	1.323	1.375	4.32	4.59
		Tryptophan	0.761	0.784	0.549	0.566	1.310	1.350	4.26	4.53
15th Dec.	Without compost	Control	0.590	0.603	0.407	0.423	0.997	1.026	2.18	2.43
		Glycine	0.674	0.696	0.477	0.491	1.152	1.187	3.09	3.46
		Tryptophan	0.668	0.692	0.475	0.494	1.143	1.186	3.03	3.38
	22 g compost pot^{-1}	Control	0.607	0.619	0.423	0.432	1.029	1.051	2.33	2.66
		Glycine	0.708	0.736	0.505	0.525	1.213	1.261	3.55	3.87
		Tryptophan	0.702	0.723	0.502	0.516	1.204	1.239	3.46	3.80
	33 g compost pot^{-1}	Control	0.623	0.647	0.434	0.450	1.057	1.097	2.54	2.88
		Glycine	0.744	0.766	0.535	0.552	1.279	1.318	4.00	4.31
		Tryptophan	0.741	0.770	0.527	0.548	1.268	1.318	3.95	4.28
	44 g compost pot^{-1}	Control	0.641	0.653	0.450	0.459	1.090	1.112	2.71	3.07
		Glycine	0.777	0.807	0.563	0.586	1.341	1.393	4.47	4.76
		Tryptophan	0.772	0.797	0.558	0.575	1.331	1.372	4.39	4.67
30th Dec.	Without compost	Control	0.580	0.593	0.399	0.415	0.979	1.008	1.99	2.24
		Glycine	0.654	0.674	0.461	0.475	1.114	1.149	2.86	3.18
		Tryptophan	0.648	0.670	0.454	0.473	1.102	1.143	2.79	3.14
	22 g compost pot^{-1}	Control	0.594	0.606	0.412	0.420	1.006	1.026	2.25	2.51
		Glycine	0.687	0.714	0.487	0.506	1.173	1.220	3.23	3.60
		Tryptophan	0.678	0.699	0.484	0.498	1.162	1.197	3.13	3.52
	33 g compost pot^{-1}	Control	0.614	0.638	0.425	0.443	1.039	1.081	2.40	2.76
		Glycine	0.736	0.744	0.515	0.531	1.251	1.275	3.68	4.04
		Tryptophan	0.715	0.738	0.511	0.530	1.227	1.268	3.59	3.96
	44 g compost pot^{-1}	Control	0.632	0.645	0.441	0.449	1.073	1.095	2.60	2.95
		Glycine	0.755	0.786	0.544	0.566	1.299	1.352	4.17	4.51
		Tryptophan	0.751	0.775	0.542	0.558	1.293	1.332	4.10	4.38
LSD at 5%			0.010	0.005	0.005	0.005	0.011	0.008	0.05	0.05

B- Essential Oil Production.

Fig (12) shows that transplanting of feverfew plants on 15th Dec caused increasing the essential oil (%) more than other dates. On the other hand, transplanting of feverfew plants on 1stDec came in the second order, while transplanting of feverfew plants on 30thDec came in the third order, such effect was the same during the two seasons of the experiment.

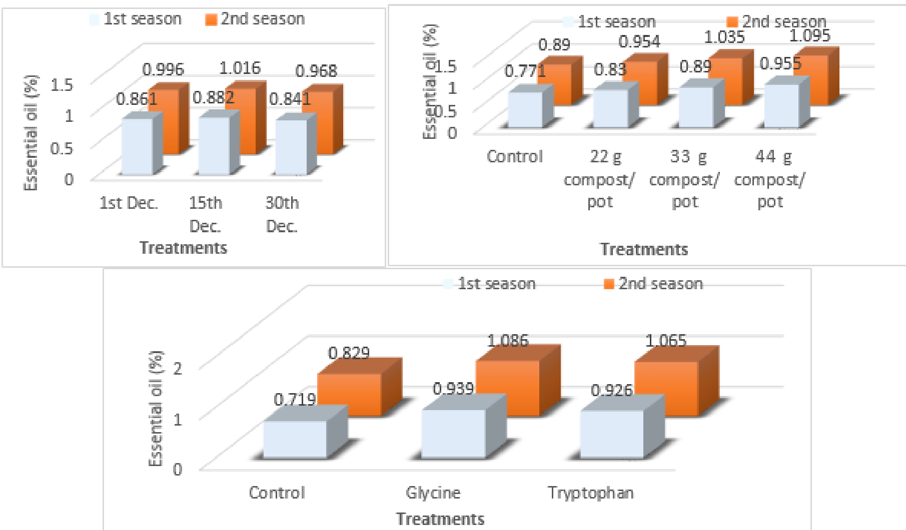

Fig. 12. Effect of planting dates, compost additions and foliar spraying with amino acids on essential oil (%) of feverfew at 2018 and 2019 seasons.

Concerning the individual effect of compost additions, Fig 12 illustrate that addition of compost at rate of 44.0 (g pot^{-1}) in pots contained sandy soil was superior treatment for essential oil (%) of feverfew plants as compared to other compost levels, where the compost levels sequence from top to less for essential oil (%) were 44 g compost $^{pot-1}$ > 33 g compost $^{pot-1}$ > 22 g compost $^{pot-1}$>0.0 g compost $^{pot-1}$. With regard to the effect of glycine and tryptophan, the same Fig show that feverfew plants sprayed with glycine had the highest values of essential oil (%) followed by tryptophan, while the lowest values were recorded with control (sprayed with tap water).Going along with combination treatments among planting dates, compost levels and amino acids, it was obvious from Table 4 that combination of 15th Dec as transplanting date + 44.0g compost pot^{-1} + glycine at rate of 1mg l^{-1} resulted in significant increase in the essential oil (%) of feverfew plants over all other combined treatments. While, the lowest values of essential oil (%) were recorded with plants transplanted on 30th Dec

Table 4. Interaction effects among planting dates, compost and foliar application of amino acids on essential oil (%) of feverfew plant at 2018 and 2019 seasons.

Treatments (Characters)			Essential oil (%) 2018	Essential oil (%) 2019
1st Dec.	Without compost	Control	0.662	0.761
		Glycine	0.826	0.942
		Tryptophan	0.817	0.947
	22 g compost pot^{-1}	Control	0.698	0.817
		Glycine	0.902	1.072
		Tryptophan	0.890	1.024
	33 g compost pot^{-1}	Control	0.738	0.871
		Glycine	0.974	1.131
		Tryptophan	0.959	1.102
	44 g compost pot^{-1}	Control	0.775	0.875
		Glycine	1.053	1.232
		Tryptophan	1.036	1.180
15th Dec.	Without compost	Control	0.678	0.800
		Glycine	0.855	0.975
		Tryptophan	0.841	0.973
	22 g compost pot^{-1}	Control	0.716	0.809
		Glycine	0.922	1.060
		Tryptophan	0.911	1.038
	33 g compost pot^{-1}	Control	0.747	0.867
		Glycine	0.991	1.150
		Tryptophan	0.982	1.149
	44 g compost pot^{-1}	Control	0.791	0.893
		Glycine	1.085	1.267
		Tryptophan	1.065	1.213
30th Dec.	Without compost	Control	0.643	0.759
		Glycine	0.811	0.924
		Tryptophan	0.801	0.929
	22 g compost pot^{-1}	Control	0.689	0.780
		Glycine	0.876	1.006
		Tryptophan	0.866	0.979
	33 g compost pot^{-1}	Control	0.729	0.852
		Glycine	0.949	1.082
		Tryptophan	0.938	1.107
	44 g compost pot^{-1}	Control	0.761	0.867
		Glycine	1.024	1.188
		Tryptophan	1.008	1.139
LSD at 5%			0.020	0.022

Discussion

This study intended to assess the performance of feverfew plants grown on sandy soil at different planting dates (1st, 15th and 30th December) using different levels of compost (0.0, 22, 33 and 44 g compost pot^{-1}) with foliar application of different amino acids *i.e*., glycine and tryptophan.

Date of planting is an important management factor for aromatic and medicinal plants, where change in planting date causes a great change in their performance. The increase of feverfew growth criteria may be due to difference in the average air temperature from planting date to another, where the optimum temperature for the best performance of feverfew growth is at 15st December date, thus increasing in plant growth criteria, while the change of temperature on 1st and 30th December date leads to that the feverfew plants have not adequate opportunity for photosynthesis thus decrease in plant growth parameters. These findings are in harmony with the obtained results of Zeynali *et al.,* (2008) they found that planting date significantly affected chamomile performance. On the contrary, our results aren't in agreement with Mirshekari and Siyami (2006) who reported that there is no significant difference among growth criteria of yarrow plants from sowing dates of 5th and 20th May. Also, results in Table 4 and Figs from 5 to 11 show that planting date of 15 th Dec resulted in increasing all chemical traits of feverfew plants compared to dates of 1st and 30th Dec. El-Sherbeny *et al*., (2007) on *Ruta graveolens* plants, Barzegar *et al*., (2013) on fennel plant and Kakaraparthi *et al*., (2013) on *Withania somnifera* plants confirmed the effect of planting dates on chemical traits. Concerning the effect of transplanting dates on essential oil productivity of feverfew plants, it was clear the maximum values were recorded as a result of transplanting date at 15th of December. The increment of essential oil productivity during the mid-December more than in the late one may be due to the rise in temperature and day length in 15th of December and its decrease in 30th of December in both seasons. Also, the circumstances for oil production is suitable when feverfew plants transplanted on 15th Dec more than 1st of Dec because of the temperature is more suitable. These results are in harmony with the obtained findings by Wafaa *et al.,* (2017) on fennel plants.

The superiority of feverfew plants fertilized with compost is may be due to compost high contains of nutrients and organic matter according to our analysis (Table 2) and these finding are in agreement with Massoud *et al*., (2016) who reported that compost is essential source for raising soil fertility and addition of compost increased shoot length (cm), fresh and dry weights (g $plant^{-1}$) of yarrow (*Achillea millefolium* L.) plants. Also, these results are in harmony with the finding of Ali *et al*., (2017) who revealed that vegetative growth criteria of fennel plants significantly increased as the compost level addition increased. Also, the using compost at different rates led to increasing in all chemical traits of feverfew plants. This primitive influence of compost may be due to compost supplies feverfew plants with nutrient as well as improves physical properties and fertility of sandy soil used. The increasing application level in pots causes increasing the positive effect on soil properties, therefore, improvement of feverfew plants performance and their nutrients uptake. These results are in harmony with the obtained findings of Mohamed *et al.*, (2020) who reported that compost caused the decline of soil pH value, thus increasing the availability of all nutrients except molybdenum element. Similar results were reported for improving plant chemical traits due to compost addition by Massoud *et al*., (2016) who found that chemical constituents on Yarrow plant leaves such as N P K nutrients (%), photosynthetic pigments *i.e.,* chlorophyll a, b, total chlorophyll and carotenoids content (mg/g FW) and total carbohydrates (%) increased as the level of addition compost increased. The increase in flowering head essential oil production with the increase of compost levels might be due to improved role to supply the feverfew plants with the required micro and macronutrient elements which play an important role in the metabolic processes such as photosynthesis, respiration and carbohydrate synthesis. Positive effects of compost on secondary metabolites have been reported by several investigators for a variety of medicinal and aromatic species, Hussein *et al.,* (2006) on *Dracocephalum moldavica*; Hussein *et al.,* (2012) on *Plantago Ovata*; Massoud *et al*., (2016) on *Achillea millefolium*.

Treating the feverfew plants with both glycine and tryptophan produce the highest growth performance and resulted in significant increases in all chemical traits and essential oil production as compared to tap water foliar application (control).The beneficial effect of both glycine and tryptophan attribute to their role in the synthesis of protein, amines, terpenoids, alkaloids, vitamins, enzymes, and plant hormones that control various plant processes. Amino acids are not only building blocks of proteins but also precursors for a myriad of other molecules that serve important functions in plants. The present results are in accordance with the findings of Gendy and Nosir (2016) they mentioned that, amino acids provide plant cells with an immediately available source of nitrogen, which generally can be taken by the cells more rapidly than inorganic nitrogen. The ameliorative effect of both glycine and tryptophan acids might be linked to the observable increase in NPK nutrients (Table 5 and Fig 5,6 and 7), photosynthetic contents (Tables5 and Figs 8,9,10 and 11). Also, the foliar spraying with amino acids positively reflect on essential oil production. Similar results were reported by Gendy and Nosir., 2016and Abd-Elkader *et al.,* 2020.

CONCLUSION

According to the obtained results, feverfew plants transplanted on 15^{th} Dec in pots contained 15 kg of sandy soil mixed with 44g compost and sprayed with glycine at rate of 1.0 mgl^{-1} as a combined treatment is the best treatment that could be recommended to enhance growth performance of feverfew plants (*Tanacetum parthenium* L.) and obtain the highest essential oil percentage.

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تأثير مواعيد الزراعة والكومبوست والرش الورقي ببعض الاحماض الامينية على النمو والمحتوي الكيمائي والزيت الطيار لنباتات الفيفرفيو (أقحوان زهرة الذهب)

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يعد تحسين إنتاج النباتات الطبية والعطرية في مصر هدفًا مهمًا للغاية في الوقت الحاضر. لذلك، أجريت تجربتان أصص في المزرعة الخاصة بالنباتات الطبية والعطرية بكلية الزراعة، جامعة المنصورة، مصر خلال موسمي 2018 و2019 لدراسة استجابة نباتات الفيفرفيو (أقحوان زهرة الذهب أو زهر اللبن) لمواعيد زراعة مختلفة (1 ديسمبر، 15 ديسمبر، 30 ديسمبر)، إضافة الكمبوست بمعدلات مختلفة (0.0، 22، 33 و44 جم لكل اصيص) والرش الورقي بالأحماض الأمينية مثل الجليسين والتربتوفان تحت ظروف التربة الرملية. كان التصميم التجريبي عبارة عن قطع منشقة مرتين بثلاث مكررات. تم قياس معايير النمو الخضري مثل الأوزان الطازجة والجافة، ارتفاع النبات وعدد الأفرع، أيضا تم تقدير الصفات الكيميائية مثل النيتروجين والفسفور والبوتاسيوم ومحتوى الكلوروفيل والكاروتين وكذلك نسبة الزيت الطيار. أظهرت النتائج أن نباتات الفيفرفيو (أقحوان زهرة الذهب أو زهر اللبن) المزروعة في 15 ديسمبر تمتلك أعلى قيم لجميع الصفات المذكورة أعلاه مقارنة بمواعيد الزراعة الأخرى. فيما يتعلق بتأثير الكمبوست كانت أعلى القيم ناتجة من إضافة 44 جم كومبوست للأصيص يليها إضافة 33 جم كومبوست للأصيص ثم إضافة 22 جم ومعاملة المقارنة (الكنترول) (بدون إضافة كومبوست) تأتي مؤخرا. تسبب الرش الورقي بكل من الجليسين والتربتوفان في زيادة واضحة في جميع الصفات المذكورة أعلاه مقارنة بالنباتات التي تم رشها بماء الصنبور (كنترول). علاوة على ذلك، كانت القيم مع الجليسين أعلى من القيم مع التربتوفان. بشكل عام، تم تسجيل أعلى القيم لجميع الصفات المذكورة أعلاه عند زرعة نباتات الفيفرفيو (أقحوان زهرة الذهب أو زهر اللبن) في 15 ديسمبر في أصص تحتوي على 44 جم كومبوست مع الرش الورقي من الجليسين بمعدل 1 ملجم/ لتر.