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Enhancement of Vegetative Growth Criteria and Accumulation of Secondary Metabolites by Using Compost Tea and Paclobutrazol on Henna (*Lawsonia inermis* L.) Plants

M.A.M. Abdel-Mola, [1*], M.A. Aboel-Ainin, [2] and A.M. Ayyat, [3]
[1]*Department of Horticulture, Faculty of Agriculture, Beni-Suef University, Egypt.*
[2]*Department of Biochemistry, Faculty of Agriculture, Beni-Suef University, Egypt.*
[3]*Department of Medicinal and Aromatic plants, Faculty of Agriculture, Beni-Suef University, Egypt.*

A POT experiment was carried out during the two successive seasons of 2018 and 2019 at Beni-Suef governorate, Egypt, to investigate the effect of compost tea and foliar-spray application of paclobutrazol (PBZ) on vegetative growth characteristics and some chemical constituents of henna plants.

Obtained results revealed that the best vegetative growth characters (plant height, number of main branches/plant, number of lateral branches/main branches, leaves number per plant, leaves fresh and dry weights/plant), photosynthetic pigments (chlorophyll a, b and carotenoids) and chemical characteristics (total carbohydrates, tannins, lawsone and NPK percentages), were obtained due to the use of the all levels of compost tea (15, 30 and 60 ml/l). Concerning paclobutrazol treatments, all of the prementioned characters except plant height, chlorophyll b and phosphorus percentage were considerably augmented due to PBZ treatments.

There for, it could be advised from the environmental point of view, to supply henna plants with compost tea 60 ml/l, in combination with 100 or 150 ppm of paclobutrazol in order to obtain the best leaves, lawsone and tannins yield of henna plants.

Keywords: Henna (*Lawsonia inermis* L.), Compost tea, Paclobutrazol (PBZ), Tannins, Lawsone.

Introduction

Henna (*Lawsonia inermis* L.) plant belongs to the family: Lythraceae. It is defined as a wild plant that can be used as an ornamental plant in the landscaping field. In ancient times in Asia and North Africa, it was used in both medicinal and cosmetic aspects (Semwal et al., 2014). Henna played a vital role in the everyday lives of some ancient cultures, it has a beneficial psychological effects and is traditionally used in different celebrations and festivals, as well as, personal decoration (Hema et al., 2010). Every part of the plant has medicinal benefits (Chaudhary et al., 2010) and used in alternative (traditional) medicine to treat a large number of diseases such as rheumatoid, heart disease, headache, fever, Ulcers, leprosy, gonorrhea, diabetes and diarrhea (Jayaweera, 1981, Reddy, 1988, Chaudhary et al., 2010 and Semwal et al., 2014).

The phytochemicals are those chemical compounds that occur naturally in plants and are responsible for their medicinal properties. The different constituents isolated from the leaves, (1) Napthoquinone derivatives such as Lawsone (2-hydroxy 1,4-naphthoquinone) (Dixit et al., 1980) and 1,3-dihydroxy naphthalene, 1,4-napthaquinone, 1,2-dihydroxy-4- Glucosylnaphthalene (Afzal et al., 1984), (2) Phenolic compounds like, Lawsoniaside, (+)-Syringaresinol, (+)-Pinoresinol and Isoscutellarin (Cuong et al., 2010), (3) Sterols

Corresponding author: Mostafa Abdel-Mola, E-mail: mostafa.abdo@agr.bsu.edu.eg, Tel. 01002446485
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including Stigmasterol and β-Sitosterol (Alam et al., 1992), (4) Flavonoids such as Apigenin-7-glucoside, Apigenin-4-glycoside, Luteolin-7-glucoside, Luteolin-3-glucoside (Afzal et al., 1980).

Compost tea is a type of plant nutrition created by soaking compost in water for a length of time in order to extract soluble organic materials and beneficial microbes (Kelley, 2004, Scheuerell and Mahaffee, 2004). It enhances the physical and chemical properties of the soil. It improves soil content of organic matter, its ability to retain moisture, and microbial community diversity. It also provides the required macro and micro nutrients for plant growth, which makes contributions to plant growth promotion (Heather et al., 2006). More benefits of compost tea, reducing salt accumulation in the soil as well as developing soil pH storage capacity by microbial diversity (Radovich and Arancon, 2011).

Paclobutrazol (PBZ) is one of the regulating plant growth and belongs to triazole compounds, it used for a growth retardant of some woody trees, shrubs and ornamental plants by suppresses gibberellic acid biosynthesis intervention (Rademacher, 2000).

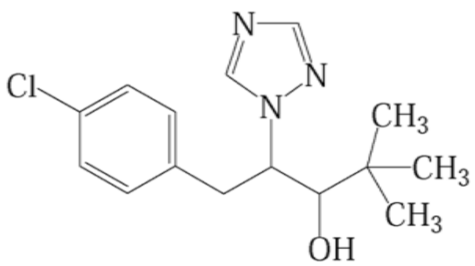


Fig. 1. Chemical structure of paclobutrazol.

The objective of the current study was to investigate the impact of foliar-spray application of paclobutrazol (PBZ) concentrations with various compost tea levels on vegetative growth criteria and accumulation of secondary metabolites (SMs) of henna (*Lawsonia inermis* L.) plants.

Materials and Methods

Experimental design and procedure

This investigation was conducted during two consecutive seasons of 2018 and 2019 at nursery of Horticulture department and Laboratory of Biochemistry, Faculty of Agriculture, Beni-Suef University, Egypt. The experimental design was split-plot in randomized complete block design with three replicates, compost tea represented in the main plots at four application (0, 15, 30 and 60 ml/l) and sub-plot displayed at four concentrations of paclobutrazol (0, 50, 100 and 150 ppm). In the first week of March, one-year-old henna seedlings were planted in containers (30 × 30 cm), each contained one seedling, for both seasons, filled beforehand with field clay loam soil. The characterizations of the experimental soil (Jackson, 1973) are shown in Table (1). Plants were pruned from the soil surface to 25 cm high after three weeks. Meanwhile, the plants were cut as the same height in the second cut. In the second season, the same procedures were followed.

Aerated compost tea created by the blending of ripe compost produced by the Egyptian solid waste recycling company (Organic Nile Compost) which located in New El-Minia City with distilled water in ratio of 1:5 (w/v). Molasses were added at 2% in order to stimulate microbial growth. Using a fish tank bubbling pump at room temperature for 72 hours, all the contents were continuously aerated (Ibrahim et al., 2019).

As a soil drench application, four doses of 0,15, 30 and 60 ml/l of compost tea were supplied every 15 days from the first of April to the end of November in both experimental seasons. Some chemical characteristics of compost and compost tea (A.O.A.C., 1995) are shown in Tables (2 and 3).

Henna seedlings were sprayed with three concentrations of paclobutrazol (PPP-333) at 50, 100 and 150 ppm two times every cut in both seasons as a foliar application. The first spray was performed on 1st May and September for first and second cuts, respectively, in both seasons, while, the second one was sprayed three weeks after the first one, tap water was used to treat the control plants. Wetting agent (Triton B at 0.1%) were added. The plants were sprayed by a hand sprayer with varying concentrations of PBZ until the point of running off.

Recorded data

Every season, harvesting was done in two cuts, the first in the last week of July and the second in the last week of November. All the following data were recorded by averaging the two cuts.

Features of vegetative growth

The vegetative growth was measured as plant height (cm), number of main branches/plant, number of lateral branches/main branch, leaves number per plant and leaves fresh and dry weights/plant (g).

TABLE 1. Physical and chemical characterizations of the used soil (Jackson, 1973).

Soil property			Textural Class	OM %	$CaCo_3$ %	pH 1:2.5	EC, dSm^{-1}	Exch. Cations (mg/100 g soil)						
Clay %	Silt %	Sand %						N%	P%	K^+	Ca^{++}	DTPA (Ext. ppm) Fe	Zn	Mn
42.80	30.20	27.00	Clay	1.5	2.25	7.65	3.35	0.09	14.25	2.72	29.40	2.45	3.05	7.85

TABLE 2. Physical and chemical properties of compost.

Properties	Dry weight of 1 m^3	Fresh weight of 1 m^3	Moisture (%)	pH (1:10)	E.C. (dSm^{-1})	Total N %	Org. matter %	Org. carbon%
Value	450 kg	650-700 kg	25-30	7.5-8	2-4	1-1.4	32-34	18.5-19.7
Properties	**NaCl %**	**Total P %**	**Total K %**	**Fe ppm**	**Mn ppm**	**Cu ppm**	**Zn ppm**	**C/N ratio**
Value	1.1-1.75	0.5-0.75	0.8-1.0	150-200	25.56	75-150	150-225	18.5-14.1

TABLE 3. Some chemical characteristics of compost tea.

pH	E.C. (dSm^{-1})	N (ppm)	P (ppm)	K (ppm)	HCO3	CL	SO4
7.2	3.95	140.5	16.2	212.5	13.8	22.5	41.2

Determination of chemical components

Photosynthetic pigments

According to Moran (1982), Three weeks following the last application of the treatments, fresh leaf samples were taken from the mid-section of the plants to determine chlorophyll a, b, and carotenoids as mg/g f.w.

Total carbohydrates percentage

According to Dubois et al. (1956) total carbohydrates percentage in dry leaves were measured.

Tannins percentage

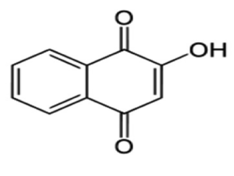
The tannin contents were determined using Folin-Denis's Reagent as described by Makkar et al. (1993). In that method, a standard calibration curve was prepared and the Absorbance (A) against concentration of tannins at specific wave length was estimated as follows:

Suitable aliquots of the tannin-containing extract (initially: 0.05, 0.2 and 0.5 mL) were pipetted in test tubes, the volume was made up to 1.00 mL with distilled water, then 2.5 mL of sodium carbonate reagent were added. Then the tubes were shaken and the absorbance was recorded at 725 nm after 40 min. The amount of tannins were calculated as tannic acid equivalent from the standard curve.

Lawsone pigment percentage

The natural dye henna is commonly known as lawsone (2-hydroxy, 1,4-naphthoquinone). Lawsone percentage in the dried henna leaves were estimated as described by Pratibha and Korwar (1999). 100 mg of ground henna powder for each sample, which was taken from henna leaves after being air-dried in the shade and then soaked in 20 ml distilled water in a test tube for two hours. The solution was placed in a centrifuge at 5000 rpm for 20 minutes to get a clear solution. Then it was transferred to another test tube, as the concentration was estimated on the basis of color intensity by a spectrophotometer at a wave length (452 nm). The standard natural lawsone (Sigma-Aldrich Com.) was used to prepare the stock solution. The percentage of Lawson dye was calculated according to the following equation:

$$\text{Lawsone percentage} = \frac{\text{lawsone content mg/g}}{1000} \times 100$$



2-hydroxy- 1,4-naphthoquinone

Fig. 2. Chemical structure of lawsone.

Statistical analysis

The experimental data collected were susceptible to (ANOVA) Statistical analysis of variance by MSTAT-C (1986). According to Mead et al. (1993), L.S.D. test at 5% was used for comparing the means of the collected data.

Results

Influence of compost tea, paclobutrazol and their interactions on vegetative growth traits (plant height (cm), number of main branches/plant and number of lateral branches / main branch)

It is pronounce from Table (4) that the effect of three compost tea treatments was significant in both experimental seasons compared with untreated plants. The highest values were resulted from supplying plants with 60 ml/l compost tea (79.9 and 79.3 cm for plant height, 4.98 and 5.08 for number of main branches/plant and 5.16 and 5.04 for number of lateral branches/main branch) in the two experimental seasons, respectively.

Influence of paclobutrazol concentrations

Data presented in Table (4) stated that application of three paclobutrazol concentration treatments 50, 100 and 150 ppm significantly decreasing plant height in comparison with control. Whilst, increments in number of main branches/plant and number of lateral branches/main branch. The highest concentration of PBZ (150 ppm) gave the highest number of main branches/plant (5.39 and 5.53) and number of lateral branches/main branch (5.61 and 5.73) in the first and second seasons, respectively, comparing to the control treatment (3.87 and 3.79 for number of main branches/plant) and (3.84 and 3.97 for lateral branches/main branch) in both seasons, respectively.

Influence of the interaction between compost tea and paclobutrazol

The interaction between compost tea and paclobutrazol concentrations, for plant height, number of main branches/plant and number of lateral branches/main branch, was significant effect in both seasons.

TABLE. 4. Influence of compost tea, paclobutrazol and their interactions on plant height (cm), number of main branches/plant and number of lateral branches/main branch of henna plants during (2018 – 2019) seasons.

Compost Tea treatments (A)	Paclobutrazol concentrations (B)									
	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)
	1st season 2018					2nd season 2019				
Plant height (cm)										
Control (water)	82.5	76.7	68.3	50.5	69.5	80.4	75.5	66.3	54.2	69.1
15 ml/l	86.3	78.5	71.4	53.8	72.5	84.5	76.3	69.1	57.3	71.8
30 ml/l	89.6	84.5	75.6	55.4	76.3	87.3	79.5	74.2	59.6	75.2
60 ml/l	92.1	87.2	79.7	60.5	79.9	90.7	83.4	80.5	62.4	79.3
Mean (B)	87.6	81.7	73.8	55.1		85.7	78.7	72.5	58.4	
L.S.D. at 5%	A: 2.2	B: 3.7		AB: 7.4		A: 1.7	B: 2.6		AB: 5.2	
Number of main branches / plant										
Control (water)	3.62	3.95	4.32	5.22	4.28	3.52	3.74	4.21	5.31	4.20
15 ml/l	3.82	4.16	4.67	5.37	4.51	3.68	3.88	4.35	5.42	4.33
30 ml/l	3.97	4.85	5.25	5.41	4.87	3.85	4.47	5.32	5.65	4.82
60 ml/l	4.08	4.82	5.46	5.55	4.98	4.12	4.93	5.53	5.74	5.08
Mean (B)	3.87	4.45	4.93	5.39		3.79	4.26	4.85	5.53	
L.S.D. at 5%	A: 0.17	B: 0.26		AB: 0.52		A: 0.09	B: 0.31		AB: 0.62	
Number of lateral branches / main branch										
Control (water)	3.24	3.86	4.37	5.05	4.13	3.71	3.93	4.27	5.15	4.27
15 ml/l	3.65	3.98	4.35	5.47	4.36	3.83	3.88	4.55	5.67	4.48
30 ml/l	4.15	4.28	5.25	5.88	4.89	4.05	4.42	5.13	6.14	4.94
60 ml/l	4.33	4.42	5.87	6.03	5.16	4.27	4.58	5.36	5.94	5.04
Mean (B)	3.84	4.14	4.96	5.61		3.97	4.20	4.83	5.73	
L.S.D. at 5%	A: 0.12	B: 0.39		AB: 0.78		A: 0.15	B: 0.21		AB: 0.42	

The highest overall values for these traits were those given by the high dose of compost tea (60 ml/l) in combination with the high level of PBZ at 150 ppm, except plant height, the tallest plants were produced as a result of supplying henna plants with high dose of compost tea (60 ml/l) in combination with tab water and / or (50 ppm PBZ), without significant differences between them in most cases, as clearly illustrated in Table (4).

leaves number per plant and leaves fresh and dry weights/plant (g)

Influence of compost tea levels

As shown in Table (5) it should be noted that the compost tea has greatly affected on the leaves number per plant and fresh and dry weights of leaves/plants in the two experimental seasons. In this respect, due to compost tea levels, the highest values of leaves number per plant, fresh and dry weights of leaves were achieved at 60 ml/l followed by 30 ml/l then 15 ml/l. These growth parameters were maximized over control treatment by 24.88, 21.85 and 12.68% in the first season and by 25.14, 19.58 and 13.33% in the second one, respectively, for leaves number per plant and by 44.13, 34.64 and 25.69% in the first season and by 43.82, 33.71 and 17.98% in the second one, successively, for leaves fresh weights and by 54.30, 31.79 and 14.57% in the first season and by 51.07, 29.32 and 13.01% in the second one, consecutively, for leaves dry weights.

TABLE 5. Influence of compost tea, paclobutrazol and their interactions on leaves number per plant and leaves fresh and dry weights/plant (g) of henna plants during (2018-2019) seasons.

Compost Tea treatments (A)	Paclobutrazol concentrations (B)									
	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)
	1st season 2018					2nd season 2019				
Leaves number per plant										
Control (water)	17.3	18.1	22.1	24.5	20.50	16.7	19.3	24.3	26.1	21.60
15 ml/l	19.2	21.7	25.4	26.1	23.10	20.5	23.5	26.3	27.6	24.48
30 ml/l	21.4	25.5	26.3	26.7	24.98	22.7	25.5	26.7	28.4	25.83
60 ml/l	23.2	24.6	26.7	27.9	25.60	24.5	25.8	27.5	30.3	27.03
Mean (B)	20.28	22.48	25.13	26.3		21.10	23.53	26.20	28.1	
L.S.D. at 5%	A: 1.9	B: 1.6		AB: 3.2		A: 2.4	B: 1.7		AB: 3.4	
Leaves fresh weight (g/plant)										
Control (water)	14.2	16.5	19.3	21.7	17.9	15.8	17.1	17.9	20.4	17.8
15 ml/l	18.5	22.3	24.2	24.8	22.5	18.6	21.2	20.8	23.5	21.0
30 ml/l	20.4	24.6	25.5	25.7	24.1	21.7	24.3	23.7	25.3	23.8
60 ml/l	24.5	25.3	26.4	26.8	25.8	23.4	25.7	26.5	26.7	25.6
Mean (B)	19.4	22.2	23.9	24.8		19.9	22.1	22.2	24.0	
L.S.D. at 5%	A: 2.7	B: 2.3		AB: 4.6		A: 2.1	B: 1.9		AB: 3.8	
Leaves dry weight (g/plant)										
Control (water)	4.61	4.88	6.45	8.22	6.04	4.45	5.12	6.74	7.95	6.07
15 ml/l	5.23	5.64	7.17	9.63	6.92	4.87	6.05	7.45	9.08	6.86
30 ml/l	6.14	7.05	8.60	10.10	7.96	5.64	7.33	8.66	9.78	7.85
60 ml/l	7.85	8.33	9.75	11.30	9.32	6.88	7.95	10.32	11.50	9.17
Mean (B)	5.96	6.48	7.99	9.81		5.46	6.61	8.29	9.58	
L.S.D. at 5%	A: 0.63	B: 0.58		AB: 1.16		A: 0.71	B: 0.83		AB: 1.66	

Influence of paclobutrazol concentrations

Collected data in Table (5) showed that leaves number per plant and both fresh and dry weights of leaves were increases gradually upward with the gradual increase in concentration of paclobutrazol. The most effective treatments which resulted in the highest values of leaves number per plant and fresh and dry weights of leaves in ascending order were: PBZ at 50 ppm followed by 100 ppm then 150 ppm. These vegetative growth parameters were increased by these three treatments over the control by 10.85, 23.91 and 29.68% in the first season and by 11.52, 24.17 and 33.17%, respectively, for leaves number per plant and by 14.43, 23.19 and 27.83% in the first season and by 11.05, 11.56 and 20.60% in the second one, successively, for leaves fresh weights and by 8.72, 34.06 and 64.59% in the first season and by 21.06, 51.83 and 75.46% in the second one, consecutively, for leaves dry weights.

Influence of the interaction between compost tea and paclobutrazol

The effect of interaction between compost tea and paclobutrazol treatments, it was significant, in the two consecutive seasons. The best overall results for leaves number per plant, fresh and dry weights of leaves and branches were due to interacting between compost tea and PBZ treatments at high level (60 ml/l + 150 ppm), in the two experimental seasons.

Influence of compost tea, paclobutrazol and their interactions on chemical composition of henna plants (Photosynthetic pigments, chlorophyll a, b and carotenoids).

Influence of compost tea levels

Data presented in Table (6) illustrated that the three photosynthetic pigments, chlorophyll a, b and carotenoids contents in the fresh leaves of henna plants were greatly enhanced due to used three compost tea levels compared with untreated treatment during the two experimental seasons. The highest levels of chlorophyll a, b and carotenoids were recorded in plants receiving compost tea at 60 ml/l followed by 30 ml/l then 15ml/l.

Influence of paclobutrazol concentrations

Concerning the effect of growth retardant concentration treatments, each of chlorophyll a and carotenoids contents were positively enhanced, in both seasons, in comparison with untreated plants as clearly shown in Table (6). Maximum contents of chl. a and carotenoids were obtained from plants receiving PBZ at 150 ppm. No significant differences were detected among three PBZ treatments for chlorophyll b in both successive seasons.

Influence of the interaction between compost tea and paclobutrazol

The interaction between the main factor and the secondary factor was significant for photosynthetic pigments, except for chlorophyll b, in both seasons as clearly shown in Table (6). the highest values were obtained as a result adding compost tea at 60 ml/l and spraying plants with PZB at 150 ppm.

Total carbohydrates, tannins and lawsone percentages in dry leaves of henna plants.

Influence of compost tea levels

Data in Table (7) reveled that compost tea levels caused an increase in total carbohydrates, tannins and lawsone percentages in dry leaves of henna plants over those given by control treatment in the two experimental seasons. The maximum values of total carbohydrates percentage (20.75 and 20.43), tannins percentage (5.01 and 5.03) and lawsone percentage (1.27 and 1.25) were obtained from supplying henna plants with 60 ml/l compost tea, in both seasons, respectively. However, the control plants gave the minimum values.

Influence of paclobutrazol concentrations

Total carbohydrates, tannins and lawsone percentages in the dry leaves of *Lawsonia inermis* plants were significantly enhanced due to high and moderate PBZ concentration treatments without significant differences between them, in most cases, in both growing seasons, in comparison with those of untreated plants as shown in Table (7). The high concentration of PBZ (150 ppm) gave the highest values for the three chemical constituents in both growing seasons. Conversely, the control plants recorded the lowest values of percentages of total carbohydrates, tannins and lawsone in dry leaves of henna.

Influence of the interaction between compost tea and paclobutrazol

The interaction between two experimental factors was significant in both seasons for total carbohydrates, tannins and lawsone percentages in the dry leaves. The maximum values were obtained due to supplying the soil of henna plants with 60 ml/l compost tea in combination with spraying PBZ at 150 ppm as shown in Table (7).

TABLE 6. Influence of compost tea, paclobutrazol and their interactions on photosynthetic pigments (chlorophyll a, b and carotenoids) of henna plants during (2018-2019) seasons.

Compost Tea treatments (A)	Paclobutrazol concentrations (B)									
	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)	Control (water)	50 ppm	100 Ppm	150 ppm	Mean (A)
	1st season 2018					2nd season 2019				
	Leaves content of chlorophyll "A" (mg/ g F.W.)									
Control (water)	0.825	0.882	1.039	1.135	0.970	0.945	0.962	1.241	1.266	1.104
15 ml/l	0.905	0.941	1.125	1.275	1.062	0.995	1.185	1.325	1.388	1.223
30 ml/l	0.947	1.052	1.305	1.430	1.184	1.177	1.257	1.408	1.442	1.321
60 ml/l	1.133	1.242	1.410	1.544	1.332	1.219	1.305	1.422	1.540	1.372
Mean (B)	0.953	1.029	1.220	1.346		1.084	1.177	1.349	1.409	
L.S.D. at 5%	A: 0.064	B: 0.092		AB: 0.184		A: 0.107	B: 0.136		AB: 0.272	
	Leaves content of chlorophyll "B" (mg/ g F.W.)									
Control (water)	0.553	0.567	0.569	0.611	0.575	0.478	0.516	0.543	0.604	0.535
15 ml/l	0.572	0.585	0.593	0.628	0.595	0.535	0.551	0.577	0.624	0.572
30 ml/l	0.605	0.622	0.655	0.670	0.638	0.592	0.587	0.605	0.635	0.605
60 ml/l	0.643	0.652	0.674	0.703	0.668	0.622	0.642	0.668	0.684	0.654
Mean (B)	0.593	0.607	0.623	0.653		0.557	0.574	0.598	0.637	
L.S.D. at 5%	A: 0.32	B: N.S		AB: N.S		A: 0.042	B: N.S		AB: N.S	
	Leaves content of carotenoids (mg/ g F.W.)									
Control (water)	0.715	0.742	0.784	0.877	0.780	0.688	0.728	0.811	0.864	0.773
15 ml/l	0.754	0.782	0.842	0.892	0.818	0.734	0.765	0.842	0.872	0.803
30 ml/l	0.772	0.837	0.885	0.914	0.852	0.798	0.822	0.875	0.907	0.851
60 ml/l	0.798	0.865	0.907	0.926	0.874	0.817	0.845	0.885	0.916	0.866
Mean (B)	0.760	0.807	0.855	0.902		0.759	0.790	0.853	0.890	
L.S.D. at 5%	A: 0.017	B: 0.067		AB: 0.134		A: 0.024	B: 0.079		AB: 0.158	

Nitrogen, phosphorus and potassium percentages in dry leaves on henna plants.

Influence of compost tea levels

Data from the Table (8) declared that compost tea treatments caused a substantial increase in nitrogen, phosphorus and potassium in the dry leaves of henna plants during the two growing seasons compared to untreated plants. The highest NPK percentages resulted from the high level of compost tea (60 ml/l) followed by the moderate level (30 ml/l). While, the lowest values for the three elements resulted from untreated treatment.

Influence of paclobutrazol concentrations

From the data collected in Table (8), it is noted that the percentages of nitrogen and potassium in henna dry leaves were notably and significantly affected by different concentrations of paclobutrazol, while, that no significant differences were observed in phosphorus compared to control during the two experimental seasons. High dose treatment for PBZ (150 ppm) followed by moderate concentration treatment, 100 ppm resulted in the highest values, whereas control treatment resulted in the lowest values.

Influence of the interaction between compost tea and paclobutrazol

Concerning the interaction between compost tea and paclobutrazol treatments, it was significant in both seasons for the three elements (NPK) as indicated in Table (8). The best overall results for the three elements in both seasons were due to interacting treatments between compost tea and PBZ, such as 60 ml/l compost tea plus 150 ppm PBZ and compost tea at 60 ml/l in combination with paclobutrazol at 100 ppm without significant differences between them.

TABLE 7. Influence of compost tea, paclobutrazol and their interactions on total carbohydrates, tannins and lawsone percentages in dry leaves of henna plants during (2018-2019) seasons.

Compost Tea treatments (A)	Paclobutrazol concentrations (B)									
	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)
	1st season 2018					2nd season 2019				
Total carbohydrates percentage in dry leaves										
Control (water)	16.25	16.32	18.55	19.08	17.55	15.88	16.37	18.44	19.36	17.51
15 ml/l	17.58	18.12	19.25	19.65	18.65	16.74	17.45	18.95	20.05	18.30
30 ml/l	18.33	19.44	20.37	20.74	19.72	17.45	19.21	21.05	21.33	19.76
60 ml/l	20.17	20.34	21.05	21.45	20.75	19.82	19.65	20.77	21.46	20.43
Mean (B)	18.08	18.56	19.81	20.23		17.47	18.17	19.80	20.55	
L.S.D. at 5%	A: 0.82	B: 0.71		AB: 1.42		A: 0.66	B: 0.1.08		AB: 2.16	
Tannins percentage in dry leaves										
Control (water)	3.95	4.12	4.38	4.67	4.28	4.12	4.26	4.63	4.82	4.46
15 ml/l	4.08	4.28	4.33	4.98	4.42	4.27	4.34	5.11	4.75	4.62
30 ml/l	4.55	4.62	4.75	5.18	4.76	4.36	4.51	5.18	5.03	4.77
60 ml/l	4.84	4.86	5.09	5.24	5.01	4.73	4.92	5.17	5.29	5.03
Mean (B)	4.36	4.47	4.64	5.02		4.37	4.51	5.02	4.97	
L.S.D. at 5%	A: 0.22	B: 0.18		AB: 0.36		A: 0.19	B: 0.24		AB: 0.48	
Lawsone percentage in dry leaves										
Control (water)	0.98	1.07	1.16	1.22	1.11	1.01	1.04	1.13	1.25	1.11
15 ml/l	1.05	1.12	1.20	1.27	1.16	1.12	1.17	1.19	1.18	1.17
30 ml/l	1.19	1.23	1.26	1.28	1.24	1.18	1.22	1.21	1.25	1.22
60 ml/l	1.24	1.18	1.31	1.33	1.27	1.21	1.24	1.26	1.27	1.25
Mean (B)	1.12	1.15	1.23	1.28		1.13	1.17	1.20	1.24	
L.S.D. at 5%	A: 0.06	B: 0.09		AB: 0.18		A: 0.04	B: 0.07		AB: 0.14	

Discussion

Recorded data illustrated that providing the soil of henna plants with the compost tea levels significantly enhanced all vegetative growth traits and chemical constituents of henna in comparison with control plants. Those results are consistent with those gathered by Milad (2003) on roselle, Abd El-Hady et al (2003) on grapevines, Abdel-Kader (2005) on henna, Abd El-Maksood (2006) and Abd El-Hamied (2007) on grapevines, Hegazi et al. (2008) on sanchezia, Mostafa et al. (2009) on orange, Abdou (2010) on pear, Haggag et al. (2014) on olive and El-Haddad et al. (2020) on *Salvia officinalis* plants.

- The use of compost tea can have a beneficial effect on vegetative growth parameters due to the availability of macro and micronutrients, including N, P, Mn, Cu, Zn and Fe (Darwish et al., 1995).
- Compost tea can provide plant surface and soil with beneficial microorganisms, fine particulate organic matter, organic acids, growth promoting factors like IAA, GA and soluble mineral nutrients (Griffin and Hutchinson, 2007, Scheuerell and Mahaffee, 2002 and Sreenivasa et al., 2010).
- The addition of organic manure (compost tea) increases the permeability of the soil and releases some organic acids and carbon dioxide during decomposition (Mashali, 1997). Nitrogen loss prevention, conservation and enhancement of manural value, increase of soil biological activity, optimistic effect on quality (Judais and Rinaldi, 2001 and Taiwo et al., 2002).

TABLE 8. Influence of compost tea, paclobutrazol and their interactions on nitrogen, phosphorus and potassium percentages in dry leaves of henna plants during (2018 and 2019) seasons.

Compost Tea treatments (A)	Paclobutrazol concentrations (B)									
	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)	Control (water)	50 ppm	100 ppm	150 ppm	Mean (A)
	1st season 2018					2nd season 2019				
nitrogen percentage										
Control (water)	2.584	2.612	2.695	2.714	2.651	2.625	2.618	2.715	2.724	2.671
15 ml/l	2.645	2.705	2.825	2.772	2.737	2.734	2.745	2.766	2.845	2.773
30 ml/l	2.805	2.820	2.865	2.902	2.848	2.795	2.933	2.875	2.988	2.898
60 ml/l	3.104	3.115	3.125	3.162	3.127	3.123	3.148	3.184	3.223	3.170
Mean (B)	2.785	2.813	2.878	2.889		2.819	2.861	2.885	2.945	
L.S.D. at 5%	A: 0.042	B: 0.035		AB: 0.070		A: 0.085	B: 0.058		AB: 0.116	
phosphorus percentage										
Control (water)	0.285	0.293	0.317	0.337	0.308	0.311	0.322	0.337	0.341	0.328
15 ml/l	0.315	0.344	0.332	0.348	0.335	0.327	0.337	0.365	0.405	0.359
30 ml/l	0.388	0.376	0.414	0.429	0.402	0.372	0.355	0.374	0.392	0.373
60 ml/l	0.422	0.435	0.453	0.449	0.440	0.395	0.429	0.415	0.435	0.419
Mean (B)	0.353	0.362	0.379	0.391		0.351	0.361	0.373	0.393	
L.S.D. at 5%	A: 0.037	B: N.S (0.047)		AB: 0.094		A: 0.033	B: N.S (0.044)		AB: 0.088	
Potassium percentage										
Control (water)	0.805	0.818	0.827	0.863	0.828	0.790	0.831	0.842	0.904	0.842
15 ml/l	0.832	0.829	0.856	0.944	0.865	0.822	0.847	0.924	0.896	0.872
30 ml/l	0.874	0.884	0.923	0.972	0.913	0.864	0.918	0.948	1.015	0.936
60 ml/l	0.952	0.965	0.984	1.038	0.985	0.942	0.983	0.978	1.025	0.982
Mean (B)	0.866	0.874	0.898	0.954		0.855	0.895	0.923	0.960	
L.S.D. at 5%	A: 0.026	B: 0.029		AB: 0.058		A: 0.019	B: 0.033		AB:0.066	

Spraying henna plants with paclobutrazol concentrations led to significant impact in most vegetative growth characters and chemical composition compared to untreated plants. Similar conclusions were reported by Al-Jamaan (2008) on conocarpus trees and Mazher et al. (2014) on *Schefflera arboricola* plants. Paclobutrazol's role in the augmentation for chl. a and b obtained from the current trail were similar to those found by Abbas (1994) on *Celosia argent,* Abdel-Kader (2005) on henna and Mazher et al. (2014) on *Schefflera arboricola* plants. As a consequence of the PBZ application, the enhancement of carbohydrates % in dry leaves was also insured by Abo-Elhasan et al. (2018) on *Callistemon citrinus* Plant. Youssef and Abd El-Aal (2013) stated that PBZ application on *Tabernaemontana coronaria* resulted in a significant increase in the leaf content of NPK. Also, Sharaf-Eldien et al. (2017) on *Zinnia elegans* came to the similar results on PK, while, nitrogen percentage significantly decreased with increasing rate of PBZ spraying.

The influence of the paclobutrazol on henna plants could be evaluated in the light of biological and physiological functions which was implemented by many researches as follow:

- The reduced in plant height of paclobutrazol-treated plants may be attributed to its inhibitory action on GA biosynthesis, Preventing the conversion of kaurene to kaurenoic acid, leading to the production of gibbrellin, which is involved in cell division (Fletcher et al., 1982; Rademacher et al., 1987 and Bekheta et al., 2003).

- Paclobutrazol helps to minimize the synthesis of auxins and their function in plants via increasing the activity of IAA-oxidase and decreasing the transition rate from tryptophan to IAA (El-Kady, 2002).
- The increase in number of main branches/ plant, number of lateral branches/main and branch diameter, resulting from spraying paclobutrazol as a growth retardant may be due to the elevated level of cytokinins followed by decreased levels of IAA and GA leading to inhibition from the apical domination of the main stem (Singh and Bist, 2003 and El-Kady, 2002).
- The foliar application of paclobutrazol on henna plants led to enhance of chlorophyll a and b, this may be attributed to increase the stimulation of stomata regulation (Navarro et al., 2007) and more densely packed chloroplasts per unite leaf area as a result of decreased leaf elongation and improved chlorophyll biosynthesis. Furthermore, triazol has been suggested to promote synthesis of cytokinin, which increases chloroplast differentiation, biosynthesis of chlorophyll and inhibits degradation of chlorophyll (Fletcher et al., 2000).
- PBZ reduces plant growth without directly affecting secondary metabolite biosynthetic pathways, as it inhibits downstream gibberellin synthesis in the chain of reactions leading to the production of secondary metabolites, such as tannin biosynthesis, phenolic compounds and terpenoids (Rademacher, 2000).
- The paclobutrazol treatments have resulted in an increase in total carbohydrate percentage. The explanation for this may be the increase in the efficiency of photosynthetic pigment synthesis, which has contributed to an increase in the assimilation of Co_2 leaves (Kandil et al., 2011). Also, a reduction in the operation of the amylase enzyme system, resulting in a decrease in the transition of soluble carbohydrates to insoluble sugar, dixstrene and starch (Abo-Elhasan et al., 2018).

Conclusion

Under the environmental conditions of same study, the important consideration of this study is the use compost tea and paclobutrazol to improve leaves yield, tannins and lawsone of henna plants. The highest growth and chemical composition values, in most cases, were given by fertilizing henna plants with the high doses of compost tea (60 ml/l) in combination with spraying PBZ at 100 or 150 ppm). There for, it could be advised and recommended to supply henna plants with the treatment of compost tea at 60 ml/l, dose in combination with 100 or 150 ppm of paclobutrazol PBZ in order to obtain the best leaves, lawsone and tannins yield of henna plants.

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Conflicts of interest

We would like to reassure you that this manuscript has no known conflicts of interest.

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تحسين خصائص النمو الخضري وتراكم مركبات الايض الثانوية باستخدام شاى الكمبوست والباكلوبترازول على نباتات الحناء

مصطفى عبده محمود عبد المولى [١] ، مصطفى عبد المنعم ابو العنين[٢] و احمد محمد عياط [٣]
[١]قسم البساتين - كلية الزراعة - جامعة بنى سويف - مصر.
[٢]قسم الكيمياء الزراعية - كلية الزراعة - جامعة بنى سويف - مصر.
[٣]قسم النباتات الطبية والعطرية - كلية الزراعة - جامعة بنى سويف - مصر.

أجريت تجربة اصص خلال الموسمين المتعاقبين ٢٠١٨ و ٢٠١٩ م بمحافظة بنى سويف - مصر ، لدراسة تأثير اضافة شاي الكمبوست بمعدلات (١٥ ، ٣٠ ، ٦٠ مل/لتر) كعامل رئيسي والرش الورقي لمركب الباكلوبترازول بتركيزات (٥٠ و ١٠٠ و ١٥٠ جزء في المليون) كعامل ثانوي ومقارنتها بمعاملات الكنترول وذلك على خصائص النمو الخضري وبعض المكونات الكيميائية لنبات الحناء.

وأظهرت افضل نتائج النمو الخضري المتمثلة في (طول النبات ، عدد الافرع الرئيسية للنبات ، عدد الأفرع الجانبية على الافرع الرئيسية للنبات ، عدد الاوراق للنبات ، الوزن الطازج والجاف للاوراق) وكذلك المركبات النشطة كيميائيا متمثلة في صبغات (كلوروفيل A ، B والكاروتينيدات) والنسبة المئوية للكربوهيدرات ومحتوى التانينات وصبغة اللوسون والنسبة المئوية للنيتروجين والفوسفور والبوتاسيوم في الاوراق الجافة لنبات الحناء ، نتيجة استخدام جميع مستويات شاي الكمبوست (١٥ ، ٣٠ ، ٦٠ مل/ لتر) بالمقارنة بالكنترول. أما بخصوص معاملات الباكلوبترازول ، كانت افضل النتائج لجميع معاملات النمو السابقة باستثناء ارتفاع النبات نتيجة الرش بالتركيزات العالية (١٠٠ و ١٥٠ جزء في المليون) ، بينما أعطى تركيز (٥٠ جزء في المليون) أقل القيم.

يمكن التوصية بمعاملة نباتات الحناء بالمعدل الاعلى من شاي الكمبوست (٦٠ مل / لتر) مع رش الباكلوبترازول بمعدل ١٠٠ أو ١٥٠ جزء في المليون للحصول على أفضل محصول ورقي وكذلك اعلى محتوى من صبغة اللوسون والتانينات لنبات الحناء.

الكلمات المفتاحية: الحناء ، شاى الكمبوست ، الباكلوبترازول ، التانينات ، اللوسون.