Egypt. J. Bot. **Vol. 61,** No. 2, pp. 565-578 (2021)

Egyptian Journal of Botany
http://ejbo.journals.ekb.eg/

Effect of the Pruning System and P-Fertilizer on Growth and Productivity of *Rosa damascena* mill. var. *trigentipetala* Plant

Esmat F. Ali[1,2]#, H.M. Al-Yasi[1], F.A.S. Hassan[1,3], K.H. Alamer[1,4], K. Hessini[1], H. Attia[1,5], S. El-Shazly[6, 7]

[1]Department of Biology, College of Science, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia; [2]Horticulture (Floriculture) Dept., Faculty of Agriculture, Assuit University, Assuit, Egypt; [3]Horticulture Dept., Faculty of Agriculture, Tanta University, Tanta, Egypt. [4]Biology Dept., Science and Arts College-Rabigh Campus, King Abdulaziz University, Jeddah, Saudi Arabia; [5]Biotechnology Center of Borj-Cedria, University of Tunis El Manar, Tunis, Tunisia; [6]Department of Biotechnology, Faculty of Science, Taif University, Taif, Saudi Arabia; [7] Biochemistry Dept., Faculty of Veterinary Medicin, Kaferelsheikh University, Kaferelsheikh, Egypt.

GETTING the highest flower yield with high-quality volatile oil of *Rosa damascena* Miller var. *trigintipetala* Dieck through good agricultural practices is one of the main challenges for oil production. Despite the critical role of pruning and P-fertilizer which strongly improve the flower productivity, their impacts on growth, flower yield, volatile oil and some physiological and biochemical processes are still poorly investigated on damask rose. Thus, in this experiment, two pruning levels i.e. 80 and 100cm from ground level and three rates of P-fertilizer (0, 15 and 30kg P_2O_5 ha^{-1}, respectively) were examined. The tallest plants were observed in response to the combined treatment of pruning level at 100 cm and P-fertilizer at 30kg ha^{-1}. However application of the same P-fertlizer level with pruning at 80 cm resulted in the highest new shoots number/ hill, flower yield components, oil content, relative water content, chlorophyll content, stomatal conductance, total soluble sugars, and N, P and K percentages relative to the other treatments. The flower yield was increased by 23.52% when plants pruned at 80cm and fertilized with P at 30kg ha^{-1} compared to the pruning at 100cm withought P addition. Decreasing pruning level and increasing P-fertilizer enhanced the protein content while reduced the free amino acids content. Conclusevelly, to obtain higher flower yield and volatile oil productivity, pruning damask rose plants at 80cm and P-fetilizet at 30kg ha^{-1} is recommended.

Keywords: Amino acids, Chlorophyll, Damask rose, Nutrients, Protein, Volatile oil.

Introduction

The genus *Rosa*, as a perennial floricultural shrub of Rosaceae family, includes 200 species and more than 18000-20000 cultivars (Senapati & Rout, 2008). Damask rose is cultivated commercially worldwide particularly Turkey, Morocco, Bulgaria, Saudi Arabia, Iran, France, China, India and Northern Africa (Tabaei-Aghdaei et al., 2006; Pal, 2013). Damask rose (*Rosa damascena* Mill), is one of the substantial industrial crops cultivated for the high-value of its essential oil around the world (Hassan et al., 2018; Attia et al., 2020). Among rose species, *Rosa damascena* Miller var. *trigintipetala* Dieck or Taif-rose is extensively cultivated for valuable volatile oil and its products such as rose concrete, absolute and rose water and the perfumes (Rusanov et al., 2005; Pal & Mahajan, 2017; Ali et al., 2014; Al-Yasi et al., 2020; Hassan et al., 2021). Further, the rose volatile oil is widely used in pharmaceutical, food and flavour & fragrance industries (Baydar & Baydar, 2013). Interestingly, the flower yield and its quality are critically varied due to environmental factors and culture practices especially pruning system (Shawl & Adams, 2009; Pal, 2013; Pal & Singh, 2013). Pruning is a critical

#Corresponding author email: esmatfarouk@yahoo.com
Received 26/12/ 2020; Accepted 29/3/ 2021
DOI: 10.21608/ejbo.2021.54543.1598
Edited by: Prof. Dr.: T. Galal, Faculty of Science, Helwan University, Cairo, Egypt.

productive technique for growth controlling, promoting branching and improving flowers productivity (Sarkka & Erikson, 2003). Seasonal partial or complete pruning is required in the damask rose production as a critical practice for maximizing flowers and oil productivity (Gibson, 1984). In Taif-rose production, the pruning directly participates in flowers productivity as it affects the final flowers number containing higher quality of oil. To success of pruning process, the irrigation must be prevented one month before and after the pruning process.

Pruning intensity is a climacteric factor for improving flower production in rose (Malhotra & Kumar, 2000). The new axillary buds in the pruned stems will be initiated through facilitating the physiological activities and the flower initiation develops quickly relative to non-pruned stems (Chimonidou et al., 2000). Standardizing the pruning system is very necessary to preserve the rose bushes and improve the productivity under different agro-climatic conditions (Pal et al., 2014). Pruning as a agronomic practice modulates the plant source-sink ratio that can alter canopy gas-exchange capacity (Medhurst et al., 2006). Additionally, Hassanein (2010) revealed that petals' weight and oil content raised by light and medium pruning relative to heavy pruning. Moreover, Pal & Mahajan (2017) revealed that flower production of damask rose and oil quality are highly influenced by pruning practices and plant nutrition. Hence, the inappropriate pruning system of damask rose can severely affect the productivity and quality of flowers (Admasu & Struikb, 2000).

Plant nutrition is another factor affecting the damask rose productivity (Khoshgoftarmanesh et al., 2008; Danyaie et al., 2011; Kumar et al., 2013). The ability of plants to respond well to the availability of nutrients in the soil is significant for their growth, development and proper completion of their life cycle (Secco et al., 2017). Unfortunately, due to the lack of information and technical skills on optimal levels of different nutrients and lack of specific fertilization programs, producers are unable to maximize the production of damask rose.

Among the essential nutrients, Phosphorus has a critical role in cellular structure components and has a remarkable role in several metabolic pathways because it is required as a structural ingredient in biomolecules as part of DNA, RNA, phospholipids in plasma membranes, inositol triphosphate and ATP (Loera-Quezadaa et al., 2015). Furthermore, P is important for many enzymes participated in several metabolic pathways, as well as cell division cycle progressions that are activated by phosphorylation. In turn, phosphorus plays a pivotal role in signal transduction pathways, membrane structure and metabolism (Ashley et al., 2011; Butusov & Jernelöv, 2013). Despite the great roles of P in plant nutrition, it is rapidly consumed for photosynthesis yet its resupply is slow (Karl, 2014; Lin et al., 2015). In most soils, phosphorus is considered the least available and mobile element relative to the other major elements (Ramaekers et al., 2010). Therefore, work must be done to provide this element in the environment of plant growth in a way that is suitable for absorption due to its preliminary importance for its growth and production.

Althougth the above mentioned importance of P-fertilizer, its effect on damask rose is poorly evaluated and limited information in the literature has been found. In this regard, to obtain a good yield from oil-bearing rose, the plants require 9-36kg P ha^{-1} according to the environmental conditions (Güçdemir, 2006). According to Baydar & Baydar (2013), 150kg ha^{-1} di-amonium phosphates are needed to maximize rose flower yield. Moreover, Singh & Ram (1987) recommend 26kg P ha^{-1} for high flower yield for oil rose plant. To date, no reports have been published to standardize the pruning system and P application for attaining a higher flowers yield and content of volatile oil in damask rose under field conditions. Considering the importance of both pruning system and P nutrition and due to the lack of information on their effect on the growth and productivity of damask rose, the aim of this study was to find the appropriate pruning system and P-fertilizer dose that can maximize the flower yields and volatile oil production of damask rose grown under Taif region conditions.

Materials and Methods

Two field trials were performed at a private farm, in Al Hada region, Taif Governorate, Saudi Arabia, during 2018 and 2019 seasons to standardize the effect of different pruning levels and phosphorus nutrition on the growth and productivity of damask rose (*Rosa damascena* Mill. var. *trigentipetala*) for attaining higher flowers production and quality of the volatile oil.

The experimental site is in highland region situated at the altitude of 1700m from mean sea-level (21°3845279 N and longitude 40°3459218 E).

Plant material and experimental procedure

In the current field study, uniform bushes of 9-year-old plantation of Damask rose were selected, which were cultivated at 2m between and within rows (2500 hill/ha). The following six treatments were investigated:

- Plants that pruned at 80cm and received no P fertilizer (Pr_1P_0).
- Plants that pruned at 80cm and received P fertilizer at 15kg P_2O_5 ha^{-1} (Pr_1P_1).
- Plants that pruned at 80cm and received P fertilizer at 30kg P_2O_5 ha^{-1} (Pr_1P_2).
- Plants that pruned at 100cm and received no P fertilizer (Pr_2P_0).
- Plants that pruned at 100cm and received P fertilizer at 15kg P_2O_5 ha^{-1} (Pr_2P_1).
- Plants that pruned at 100cm and received P fertilizer at 30kg P_2O_5 ha^{-1} (Pr_2P_2).

The experiment was laid out in a randomized block design (RBD) with four replicates. Each traement contained 16 hills distributed in the four trplucates. The pruning process was done on December 15th using a clean sharp pruning knife. P-fertilizer was applied at four equal doses during the growing season. The first one was applied two weeks after pruning, the rest doses were applied at 2-weeks intervals. Additionally, decomposed organic fertilizer was added immediately after pruning at a rate of 3kg $hill^{-1}$. A drip irrigation system was used; however, irrigation was prohibited at least one month before and after pruning. The plots were kept weed-free during the study by manually weeding. The same practices were repeated in the same manner for two growing seasons.

Growth parameters

By the end of the flowering season, the growth parameters; i.e. plant height (cm) and new shoots number per each old shoot were recorded. The plant height was measured from soil surface to the highest part of the stem (Wood & Roger, 2000).

Flowers yield components

Flowers from each hill were periodically harvested, and flowers weight (g $flower^{-1}$ and g $hill^{-1}$) and blind shoots (No. $hill^{-1}$) were recorded, while flowers yield (flower No. $hill^{-1}$) was daily counted through the flowering period.

Relative water content (RWC)

To estimate the RWC, the equation of Weatherley (1950) was used as follows: $(W_{fresh}-W_{dry})/(W_{turgid}-W_{dry}) \times 100$, where W_{fresh} and W_{turgid} are the fresh and turgid (after being saturated with distilled water at 4°C for 24hrs.) weights of samples and W_{dry} is the sample dry weight (oven-dried at 70°C for 48hrs.).

Stomatal conductance (SC)

Stomatal conductance (mol H_2O $m^{-2}s^{-1}$) in damask rose leaves was measured by Delta T AP4 leaf porometer, UK.

Volatile oil estimation

The flowers were manually picked early in the morning to prevent volatile oil loss. Then, the volatile oil was extracted by the hydro-distillation method using a Clevenger-type apparatus (British Pharmacopea, 1963). The oil content was expressed based on flower fresh weight. The extracted oil was dehydrated using Na_2SO_4 (Merck) and collected in a glass vial and stored at 4°C in a dark place until analyze using gas chromatography-mass spectrometry (GC-MS).

GC-MS Analysis and Quantification

The identification of the oil constituents was assayed using Varian GC CP-3800 and MS Saturn 2200 equipped with a capillary column (VF-5ms 30 × 0.25mm ID and film thickness 0.25µm). The ionization energy of the electron system was 70 eV for the detection of GC-MS. The retention indices of volatile oil constituent peaks were compared with the standards and the NIST library of the GC-MS system to identify the components.

Chlorophyll (Chl.) estimation

Random samples of fresh leaves were selected from each experimental unit for Chl. estimation. Chl. was extracted by acetone (80%). The extract absorbance was colorimetrically investigated at 645 and 663nm. Finally, the Chl. content was calculated and presented as mg g^{-1} FW according to the standard equations of Sadasivam & Manickam (1992).

Estimation of N, P and K

At the end of flowering stage, leaf samples were collected for estimating N, P and K content. The samples were ground after drying and then digested with a mixture of perchloric

acid and H_2SO_4 (1:5) as described by A.O.A.C. (1995). Leaf N content was measured using micro-Kjeldahl digestion method as described by Nelson & Sommers (1973). Phosphorus was colorimetrically determined using spectrophotometer (Pharmacia, LKB-Novaspec II) while potassium was measured by flame photometer (Sherwood Flame Photometer 410) as per standard procedure (Prasad et al., 2006).

Total soluble sugars (TSS %)

Extraction of TSS from leaf samples was carried out as described by Garcia et al. (2006). The assessment of TSS was permofmed according to the method reported by Dubois et al. (1956) using the anthrone reagent.

Free amino acids and total protein content

To determine the free amino acids and total protein content, the method of Ruiz & Romero (2002) was used. Briefly, a fresh leaf sample (0.5gm) was crushed in 5mL cold phosphate buffer (50mM KH_2PO_4, pH 7), and centrifuged at 12000 xg for 15min. The obtained supernatant was used for free amino acids and soluble protein analysis. Ninhydrin method was used to determine the total free amino acids content according to Yemm et al. (1955) and the results were expressed as mg g^{-1} FW. The Brilliant Blue G-250 reagent was used for the determination of the soluble protein content (Bradford, 1976) using BSA (bovine serum albumin) as a standard.

The statistical analysis

The obtained results of consecutive 2 years were expressed as mean ± SD (standard deviation); the results were homogenous and, therefore, pooled (n= 8) for analysis. The performance of ANOVA and data analysis were done by SPSS 13.3 and means were separated using Duncan's multiple range test at the probability level of 5% (Steel & Torrie, 1960).

Results

Growth parameters

The analyzed results showed a significant impact (P≤ 0.05) of pruning system and P-fertilizer treatments on plant height of damask rose. The highest values of plant height was recorded with Pr_2P_2 treatment relative to the other treatments. The data revealed a significant (P≤ 0.05) improvement in the number of branches (11.12 new shoots per old shoot) Pr_1P_2Treatment compared to Pr_2P_0 teatment (6.19 new shoots per old shoot) (Table 1).

TABLE 1. The effect of pruning level and P-fertilizer on growth parameters of *Rosa damascena* mill. var. *trigentipetala* plants

Treatments	Plant height (cm)	New shoots number per old shoot
Pr_1P_0	136.89 ±0.65e	7.92 ±0.09c
Pr_1P_1	139.16 ±0.69d	9.32±0.10b
Pr_1P_2	142.27 ±0.91cd	11.12±0. 09a
Pr_2P_0	144.63 ±0.89fc	6.19±0.06d
Pr_2P_1	147.51 ±1.14b	6.89±0.08d
Pr_2P_2	153.74 ±1.29a	7.56±0.07c

- Pr_1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1}, respectively.
- The values within each column followed by the same letter are not significantly different at P≤ 0.05.

RWC and SC

Significant effects were detected for the pruning system and P-fertilizer treatments on RWC and SC in damask rose leaves. Pr_1P_2 treatment resulted in higher values of both RWC and SC than those obtained by Pr_2P_0 (Fig. 1 A & B) and was was superior in this regard compared to the other treatments. Generally, the pruned-shoots at 100cm FGL lost more water than the pruned-shoots at 80cm FGL under the same dose of P-fertilizer.

Flower yield

Analysis of variance indicated that the flower yield showed a significant (P≤ 0.05) and positive relation to pruning system and P-fertilizer (Table 2). Under any P level, the flower weight and flower yield were significantly increased due to applying 80cm FGL pruning system compared to 100cm FGL. Applying the highest P level resulted in higher flower yield values relative to the other P levels at any pruning system. The treatment of Pr_1P_2 maximized the all flower yield attributes investigated in this study since it increased the flower yield by 23.52% compared to the treatment of Pr_2P_0. In the same direction, using the lower pruning system and higher dose of P-fertilizer resulted in a significant reduction in blind shoots per hill. The lowest blind shoots number was recorded with Pr_1P_2 treatment while the treatment of Pr_2P_0 recorded the highest number in this respect.

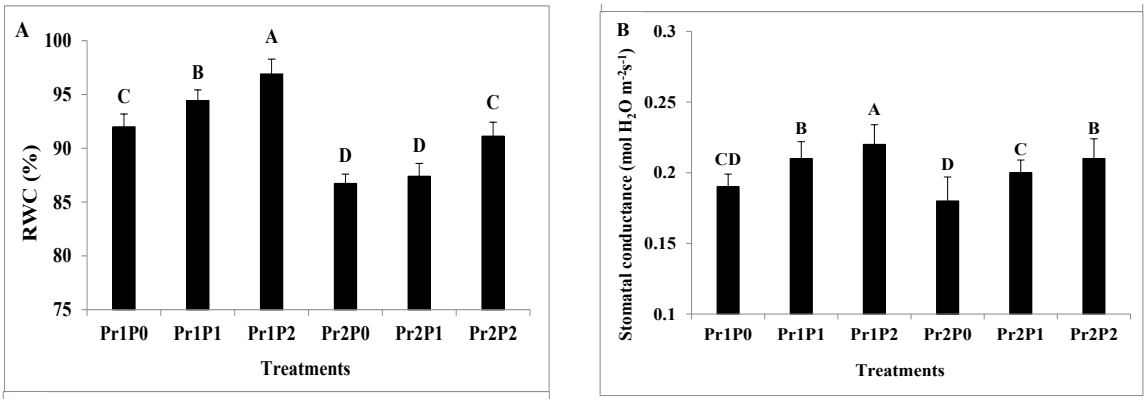

Fig.1. Impact of pruning level and P-fertilizer on relative water content (RWC) and stomatal conductance (SC) of *Rosa damascena* mill. var. *trigentipetala* plants. Pr1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1}, respectively [Values are means ± standard division. Columns with the same letter are not significantly different (P≤ 0.05)]

TABLE 2. The effect of pruning level and P-fertilizertreatments on flowers yield (flower $hill^{-1}$), flower weight (g), flower weigh (g $hill^{-1}$) and blind shoots (No. $hill^{-1}$) of *Rosa damascena* mill. var. *trigentipetala* plants

Treatments	Flower yield (flowers no. $hill^{-1}$)	Flower weight (gm)	Flowers weight (gm $hill^{-1}$)	Blind shoots (No. $hill^{-1}$)
Pr_1P_0	806.25 ±7.58c	2.68±0.02de	2160.75±22.89d	62.35±7.98d
Pr_1P_1	860.48 ±7.98b	2.83±0.01b	2435.16 ± 28.384b	52.92±7.24e
Pr_1P_2	896.61±8.94a	3.08±0.03a	2761.56 ± 29.871a	47.82±7.58f
Pr_2P_0	725.89 ±8.26f	2.53±0.02e	1836.50 ± 32.21f	94.38±0.94a
Pr_2P_1	765.56 ±8.23e	2.68±0.04d	2051.70 ± 25.18e	74.58±0.87b
Pr_2P_2	802.87± 6.98d	2.79±0.06c	2240.01±18.56c	63.27±0.81d

- Pr_1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1},respectively.
- The values within each column followed by the same letterare not significantly different at P≤ 0.05.

Volatile oil content

The averages volatile oil percentage in the fresh flowers varied from 0.038 to 0.043% depending upon the pruning system and P-fertilizer. Within the experimental treatments, Pr1P2 and Pr2P2 recorded quite higher oil content; however, no significant effect of the applied treatments on volatile oil (%) was observed. The oil yield (mL $hill^{-1}$) and productivity (L ha^{-1}) showed a significant difference among the treatments, which showed a significant (P≤ 0.05) increase by applying Pr1P2 followed by Pr1P1 treatments compared to the other treatments (Table 3).

TABLE 3. The effect of pruning level and P-fertilizer treatments on volatile oil contentof *Rosa damascena* mill. Var. *trigentipetala*flowers

Treatments	Volatile oil percentage (%)	Volatile oil yield (mL $hill^{-1}$)	Volatile oil productivity (L ha^{-1})
Pr_1P_0	0.038 ± 0.003a	0.306 ±0.042c	0.756 ± 0.037c
Pr_1P_1	0.041 ±0.002a	0.353± 0.031b	0.882 ± 0.062b
Pr_1P_2	0.042 ±0.004a	0.377± 0.038a	0.942 ± 0.0454a
Pr_2P_0	0.039 ±0.002a	0.283± 0.025d	0.707 ± 0.063d
Pr_2P_1	0.040 ±0.003a	0.307 ±0.029c	0.767 ± 0.071c
Pr_2P_2	0.043 ±0.003a	0.345 ±0.034b	0.862 ± 0.0484b

- Pr_1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1},respectively.
- The values within each column followed by the same letterare not significantly different at P≤ 0.05.

Volatile oil constituents

GC-MS analysis resulted in identifying a total of 43 constituents in rose volatile oil, which contributed to about 87.97-96.42 % of the total volume. All treatments gave a similar profile with quantitative differences. The different oil constituents in response to pruning system and P-fertilizer are reported in Table 4. The utmost percentage (96.42 %) of the identified compounds in total volume of volatile oil was attained with Pr_1P_2 treatment, while the lowest (87.97%) was observed with Pr_2P_0 treatment. The volatile oil profile showed that the main components of the volatile oil were citronellol; 19.08-19.98 % and E-geraniol (15.12-15.89%). The other important components were linalool (6.72-7.35%), nerol (6.62-7.58%), nonadecane (7.03-7.68%), α-Pinene (3.70-3.92%) and Phenyl ethyl alcohol (2.54-2.74%).

Chl. and TSS contents

The content of Chl and TSS gradually and significantly ($P \leq 0.05$) increased with decreasing the pruning level from 100 to 80 cm FGL and increasing the P-level (Fig. 2 A & B). The treatment of Pr_1P_2 recorded the highest values of both Chl. and TSS however the lowest values in this respect was recored with Pr_2P_0 treatment.

FAA and protein contents

The protein content in rose leaves was significantly increased by lowering the pruning level and increasing the level of P-nutrition. Rose plants that pruned at 80 cm FGL and fertilized with 30 kg P_2O_5 ha^{-1} recorded the highest protein content. Meanwhile, the lowest protein content was obtained by Pr_2P_0 treatment. In contrast, the treatment of Pr_1P_2 resulted in the lowest free amino acids content however the application of Pr_2P_0 gave the highest values in this respect (Fig. 3 A and B).

Nutrients content

It was observed from the obtained data in Table 5 that N, P, and K percentages in leaves were significantly ($P \leq 0.05$) enhanced by the proper pruning system and the suitable P-fertilizer dose. The highest values of N, P and K percentages were observed by Pr_1P_2 treatment while the lowest values in this respect were recorded by Pr_2P_0 treatment.

Discussion

Increasing the Flower yield of *R. damascena* was the ultimate goal for the producers and researchers worldwide. Pruning is an effective agricultural practice of flowering plants for obtaining better growth and flowering (Saffari et al., 2004). Herein, the pruning system and P-fertilizer significantly affected the investigated parameters of growth and yield of damask rose and generated satisfactory results in the case of all studied physiological attributes. The current study showed that a suitable pruning is necessary for branches to grow long enough having more flower buds resulting in higher yield. These results are probably due to the higher number of dormant vegetative buds on tall partially bushes. Therefore, we observed higher new shoots when plants were pruned at 80 cm than those pruned at 100 cm FGL. The current results are consistent with the report of Chesney (2008) who revealed that a sequence of axes was maintained from leaves to stem and root system due to partial pruning which resulted in the allocation of photosynthates. Further, a higher new shoot initiation rate had also been recorded with the top pruning system (Pal et al., 2014). In *R. damascene,* the pruning is suggested for better growth, whereas a higher branches number/shrub was produced from the plants subjected to medium pruning (Younis et al., 2013). Moreover, pruning has found to be effective in increasing the branch number of roses (Saffari et al., 2004). These results may be due to the impact of pruning on increasing the proliferation of roots that leads to an increase in the absorption of nutrients (Saifuddin et al., 2010). Regarding the enhancing effects of P-fertilizer on growth characteristics as reported by the present data, it may be due to the effects of P-fertilizer on improving the levels of plant hormones (IAA, GA_3 and cutokinins) which play pivotal roles in stimulating plant growth (Kahil et al., 2017; Huang et al., 2019). In contrast to the other nutrients necessary for plants, phosphorus is the least mobile and least available for plants under most soil conditions, whether acidic or alkaline because it is suitable for absorption in a certain range of soil pH (Ramaekers et al., 2010). Moreover, phosphorous stimulates root growth and helps plants to establish early during the growing season (López-Arredondo et al., 2014). Growth improvement occurred in this study due to P-fertilizer is in correspondence with the results of Li et al. (2003), Bindraban et al. (2020) and Schleuss et al. (2020).

TABLE 4. The effect of pruning level and P-fertilizer treatments on volatile oil constituents of *Rosa damascena* mill. var. *trigentipetala* plants

No.	RI	Compound	Pr_1P_0	Pr_1P_1	Pr_1P_2	Pr_2P_0	Pr_2P_1	Pr_2P_2
			Relative (%)					
1.	1038	α-Pinene	3.79	3.70	3.92	3.62	3.71	3.84
2.	1132	Sabinene	0.11	0.12	0.11	0.09	0.08	0.10
3.	1143	β-Pinene	0.68	0.67	0.70	0.67	0.66	0.67
4.	1186	Myrcene	1.92	1.95	1.98	1.87	1.89	1.94
5.	1216	Limonene	0.31	0.31	0.32	0.28	0.30	0.32
6.	1228	1,8-Cineole	0.21	0.22	0.21	0.19	0.21	0.20
7.	1278	p-Cymene	0.22	0.22	0.24	0.21	0.20	0.21
8.	1513	Linalool	7.24	7.35	7.26	6.72	7.01	7.12
9.	1528	*cis*-Rose oxide	0.72	0.78	0.81	0.69	0.71	0.72
10.	1542	Phenyl ethyl alcohol	2.61	2.73	2.74	2.54	2.57	2.58
11.	1553	*trans*-Rose oxide	0.62	0.64	0.65	0.57	0.59	0.61
12.	1569	Terpinen-4-ol	1.25	1.27	1.26	1.19	1.22	1.24
13.	1582	α-Terpineol	2.54	2.58	2.67	2.46	2.49	2.52
14.	1597	Nerol	7.58	7.62	7.65	6.71	6.82	7.24
15.	1608	Citronellylformate	0.22	0.25	0.26	0.18	0.17	0.23
16.	1649	Neral	0.65	0.72	0.76	0.58	0.63	0.62
17.	1662	Heptadecane	1.45	1.47	1.51	1.38	1.39	1.43
18.	1676	Geranylformate	0.32	0.34	0.35	0.28	0.27	0.29
19.	1684	1-Heptadecene	0.37	0.41	0.42	0.32	0.35	0.34
20.	1691	Citronellol	19.45	19.82	19.98	19.08	19.12	19.11
21.	1706	Geraniol	15.73	15.89	16.46	15.12	15.46	15.61
22.	1725	Geranial	2.69	2.72	2.94	2.03	2.42	2.58
23.	1737	Citronellyl acetate	0.62	0.74	0.72	0.63	0.71	0.64
24.	1742	Eugenol	1.50	1.51	1.52	1.53	1.50	1.49
25.	1745	Geranyl acetate	0.84	0.81	0.91	0.84	0.82	0.85
26	1751	Methyl eugenol	1.24	1.27	1.23	1.19	1.18	1.22
27	1757	β-Caryophyllene	0.91	0.98	0.94	0.93	0.91	0.92
28	1767	α-Guaiene	1.32	1.24	1.21	1.22	1.21	1.34
29	1779	Germacrene D	0.62	0.63	0.62	0.71	0.65	0.66
30	1786	δ-Guaiene	1.10	1.09	1.08	1.09	1.12	1.14
31	1799	Pentadecane	0.48	0.51	0.59	0.46	0.51	0.52
32	1806	Caryophyllene oxide	0.41	0.43	0.48	0.39	0.36	0.42
33	1814	Octadecane	0.34	0.38	0.42	0.32	0.30	0.33
34	1818	Nonadecene	2.52	2.64	2.72	2.24	2.35	2.62
35	1826	Nonadecane	7.10	7.47	7.68	7.03	7.08	7.12
36	1837	1-Eicosane	0.46	0.48	0.51	0.44	0.46	0.45
37	1997	Heneicosane	1.14	1.18	1.24	1.02	1.06	1.12
38	2967	Heneicosene	0.21	0.23	0.26	0.19	0.20	0.19
39	2104	(E)-3,7-Dimethyl-5-octen-1,7-diol	0.24	0.26	0.24	0.22	0.24	0.23
40	2175	α-Cadinol	0.15	0.16	0.13	0.14	0.14	0.16
41	2223	Tricosane	0.32	0.32	0.35	0.28	0.28	0.30
42	2246	(2E,6Z)-Farnesol	0.25	0.23	0.26	0.24	0.25	0.26
43	2264	(2E, 5E)-3,7-Dimethyl-2,5-octadien-1,7-diol	0.09	0.13	0.11	0.08	0.09	0.11
Total			**92.54**	**94.47**	**96.42**	**87.97**	**89.69**	**91.61**

- Pr_1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1}, respectively.
- RI is the retention indices.

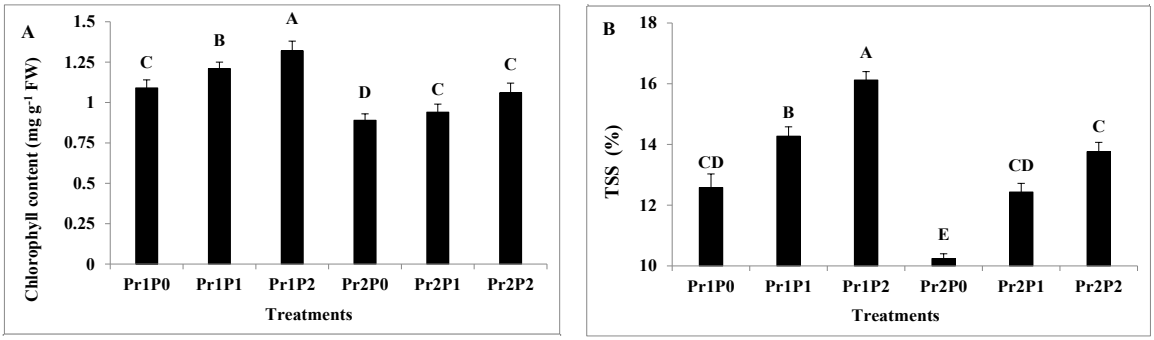

Fig. 2. Impact of pruning level and P-fertilizer on; A) TSS (%) and B) Chlorophyll content (mg g^{-1} FW) of *Rosa damascena* mill. var. *trigentipetala* plants. Pr1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1}, respectively [Values are means ± standard division. Columns with the same letter are not significantly different (P ≤ 0.05)]

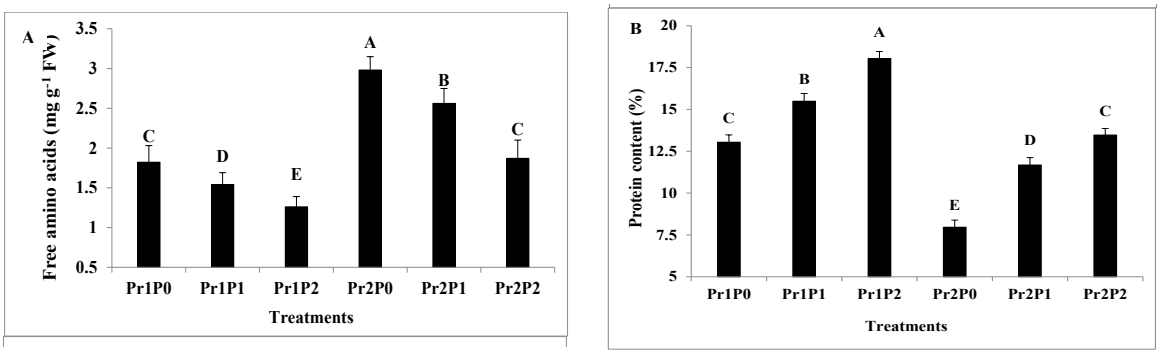

Fig. 3. Impactof pruning level and P-fertilizer on; A) free amino acids (mg g^{-1} FW) and B) protein content(%) of *Rosa damascena* mill. var. *trigentipetala* plants. Pr1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30 kg P_2O_5 ha^{-1},respectively [Values are means ± standard division. Columns with the same letter are not significantly different (P≤ 0.05)]

TABLE 5. The effect of pruning level and P-fertilizer treatments on N, P and K contents of *Rosa damascena* mill. var. *trigentipetala* plants

Treatments	N (%)	P (%)	K (%)
Pr_1P_0	2.29 ± 0.11c	0.32 ± 0.03c	2.15 ± 0.04d
Pr_1P_1	2.46 ± 0.13b	0.42 ± 0.02a	2.31 ± 0.05b
Pr_1P_2	2.58 ± 0.14a	0.45 ± 0.01a	2.37 ± 0.02a
Pr_2P_0	1.99 ± 0.05e	0.31 ± 0.01c	2.09 ± 0.04e
Pr_2P_1	2.12 ± 0.12d	0.38 ± 0.03b	2.12 ± 0.03d
Pr_2P_2	2.26 ± 0.78c	0.43 ± 0.02a	2.24 ± 0.06c

- Pr_1; pruning level at 80cm FGL, Pr_2; pruning level at 100cm FGL, P_0, P_1 and P_2 were phosphorus at 0, 15 and 30kg P_2O_5 ha^{-1},respectively.
- The values within each column followed by the same letterare not significantly different at P≤ 0.05.

For the preferable growth of oil-bearing roses, continuous rejuvenating is indispensable. In the current study, even the light pruning promoted more new shoots, whereas the maximum number of flowers was recorded with pruning at 80cm FGL. These findings may be due to the fact that the right position of pruning raised light interception within its canopy, maintained an appropriate amount of metabolic sinks and enhanced stem water potential (Hassanein, 2010). Obtaining higher RWC in the current study due to pruning at 80 cm supports this theory and found to be in accordance with the report of Van Noordwijk & Purnomosidhi (1995). Hence,

the freshness state of pruned plants and higher RWC were reflected in good water relations and enhanced the stomatal conductance. Maintaining the RWC and enhancing the SC by pruning may help in increasing the number of flowers due to maintaining higher levels of photosynthesis and nutrient supply throughout the root system (Saifuddin et al., 2010).

Increasing the flower yield due to pruning could be ascribed to the improvement of new shoots initiation that bear more flower number. Enhancing the flower yield due to increasing the branching has been previously reported by Ali et al. (2014). Improving the flowers yield due to pruning at 80cm compared to 100cm FGL could be ascribed to the outgrowth of a higher number of new shoots, which caused a temporary depletion of stored metabolic sinks from older shoots. Moreover, flowers yield depends on branches number on which flowering buds are produced (Younis et al., 2013). Akhtar et al. (2016) proved that pruning is effective for increasing flowers yield. Our results are in harmony with the report of Pal & Mahajan (2017) who reported that the proper pruning system could increase the flowers yield by improving the levels of both photosynthetic pigment and N content. Phosphorous has a pivotal role in genetic inheritance, membrane structure, signaling pathways, and metabolism, and therefore it is considered essential for all plants (Ashley et al., 2011; Butusov & Jernelöv, 2013) which may explain the enhanced flower yield due to its application. Further, increasing the shoot number as a result of applying P-fertilizer might reflect in enhancing the flowers number and thus increases the yield and productivity.

In this study, the chlorophyll content and TSS were increased due to the pruning process and P-fertilizer treatments. In the same context, Calatayud et al. (2008) revealed that pruned plants have a higher capacity to enhance photosynthesis reactions, a greater number of metabolic pathways and higher turgor pressure compared to non-manicured plants. Additionally, the pruning process promotes photosynthetic light reaction, elevates turgor pressure and increases metabolic sinks in plants (Calatayud et al., 2007). Further, the proper distribution of light within the rose canopy due to pruning led to producing an adequate amount of metabolic sinks reserve and a higher stem water potential (Saifuddin et al., 2010). In the same context, Chesney & Vasquez (2007) reported that the shoot pruning influences the processes of photosynthesis, synthesis of non-structural carbohydrates and energy. Moreover, pruning practice increases the light infiltration and distribution in plants canopy and hastens cytokinin activities, which changes the photosynthetic ability and quantum yield of leaves (Admasu & Struikb, 2000; Hossain et al., 2007). Regarding the impact of P-fertilizer on plant pigments. Taiz & Zeiger (2010) reported that Chl content was considerably increased by applying P-fertilizer treatments. This is because P is important for storage, transfers the energy in plant cells, and is essential for the photosynthesis. Furthermore, one of the roles of phosphorous in plants is that it is linked to a basic biological processes: energy production, respiration, photosynthesis, enzymatic processes, nucleic acids and cell membranes (Sharma et al., 2011; Naik et al., 2013; Anand et al., 2016). In the same line in current report, the photosynthetic pigments were improved by phosphorus released by mycorrhizal fungi or detected in moringa leaf extract (Ali & Hassan, 2014; Ali et al., 2018).

Increasing the TSS as a result of pruning has been previously observed (Adhikari & Kandel, 2015). Moreover, the total Chl content was higher in the phosphorous-treated plants and this result may be a reason for increasing number of flowers and their productivity, and the Chl was much higher with the partial pruning level compared to the full pruning level (Pal & Mahajan, 2017).

In the current study, the volatile oil content was enhanced due to pruning and P-fertilizer treatments. Further, both treatments affected the oil constituents as well. The main components detected in the volatile oil of the all treatments were heptadecane, nonadecane, eicosane, and heneicosane which in agreement with the results of Mohamadi et al. (2011). Therefore, in this study, we observed an increase in volatile oil content due to P-fertilizer. Moreover, these main components were affected by pruning processes which is in accordance with the report of Pal & Mahajan (2017) who found that the volatile oil content of damask rose was enhanced due to the pruning system and the oil main components were also improved. It has been proven that the nutrients have a positive role in secondary metabolites accumulation including volatile oils in several aromatic plants (Hassan et al., 2012;

Hassan & Ali, 2013; Heidari et al., 2014).

The N, P, and K levels in leaves were considerably increased with the treatments of pruning system and P-fertilizer. In this experiment, the percentages of N, P and K elements were enhanced in pruned shrubs at 80cm compared to 100cm FGL especially under a higher dose of P-fertilizer. These results are in accordance with those of Hossain & Fusao (2008) who recorded the increase in flower buds, sugar content and N, P and K content in leaf with pruning. Also, the content of N, P and K content in leaves was increased in P-fertilizer treated plants relative to control (Shahbazi et al., 2014). Increasing protein content with increasing P-fertilizer is in the same line with Shahbazi & Nematollahi (2019) who reported that increasing the phosphorus rates from 0 to 150 kg ha^{-1} increased protein values significantly. Moreover, an increase in P % in leaves has been reported due to P-fertilizer treatment (Li et al., 2003).

Conclusion

From the obtained results, it could be concluded that two pruning systems and P-fertilizer treatments were effective in enhancing plant growth, flower yield, oil content and quality as well as some physiological and biochemical traits studied. Pruning system and P-fertilizer maintained RWC, Chl content, SC and protein content. As well, the proper pruning level of damask rose should be at 80 cm FGL to catch up with appropriate branch growth and flower bud formation and consequently maintain a maximum flower yield and oil content. Authors suggest utilizing growth nutrients such as P-fertilizer, which is useful to increase the flower yield and oil content of damask rose, which can be vastly used for industrial purposes. Therefore, it can be concluded that Pr_1P_2 is a superior and recommended treatment for improving the flower yield, oil content and the physiological characters of damask rose.

Acknowledgments: The results presented in this paper were obtained with financial support from Taif University. The authors are grateful to Taif University (the Agency of Taif University for graduate studies and scientific research) for the financial support given to research projects on Taif-rose (Project No. 1/439/6082).

Conflict of interests: The authors declare no conflict of interest.

Authors contribution: EFA: Develop the concept, design the experiment, collection and chemical analysis, data analysis, and manuscript writing. HMA, FAH, KHA, KH, HA and SE: design the experiment, collection, chemical analysis and sharing in manuscript writing.

Ethical approval: Not applicable.

References

A.O.A.C. (1995) "*Official Method of Analysis*" 16th ed., Association of Official Analytical Chemists International, Arlington Virginia, USA.

Adhikari, S., Kandel, T.P. (2015) Effect of time and level of pruning on vegetative growth, flowering, yield, and quality of Guava. *International Journal of Fruit Science*, **15**(3), 1-12

Admasu, T., Struikb, P.C. (2000) Influence of repetitive transplanting and leaf pruning on dry matter and food production of enset (*Ensete ventricosum* Welw. (Cheesman). *Field Crops Research*, **68**, 61-74.

Akhtar, G., Akram, A., Sajjad, Y., Farooq, A., Balal, R. M., Younis, A., Lim, K. (2016) Improving flower yield of two essential oil bearing Rosa species through pruning severity. P*akistan Journal of Nutrition,* **15**(4), 328-332.

Ali, E.F., Hassan, F. (2014) Alleviatory effects of salt stress by mycorrhizal fungi and gibberellic acid on chamomile plant. *International Journal of Science and Research*, **3**(11), 109-118.

Ali, E.F., Bazaid, S., Hassan, F. (2014) Salinity tolerance of Taif roses by gibberellic acid (GA_3). *International Journal of Science and Research*, **3**, 184–192.

Ali, E.F., Hassan, F.A.S., Elgimabi, M. (2018) Improving the growth, yield and volatile oil content of *Pelargonium graveolens* L. Herit by foliar applicationwith moringa leaf extract through motivating physiological and biochemical parameters. *South African Journal of Botany,* **119**, 383-389.

Al-Yasi, H., Attia, H., Alamer, K., Hassan, F., Esmat, F., Elshazly, S., Siddiqued, K.H.M., Hessiniae, K. (2020) Impact of drought on growth,

photosynthesis, osmotic adjustment, and cell wall elasticity in Damask rose. *Plant Physiology and Biochemistry*, **150**, 133-139.

Anand, K., Kumari, B., Mallick, M.A. (2016) Phosphate solubilizing microbes: An efective and alternative approach as biofertilizers. *International Journal of Pharmacy and Pharmaceutical Sciences,* **8**, 37–40.

Ashley, K., Cordell, D., Mavinic, D. (2011) A brief history of phosphorus: from the philosopher's stone to nutrient recovery and reuse. *Chemosphere*, **84**, 737-746.

Attia, H., Al-Yasi, H., Alamer, K., Ali, E., Hassan, F., Elshazly, S., Hessini, K. (2020) Induced anti-oxidation efficiency and others by salt stress in *Rosa damascena* Miller. *Scientia Horticulturae,* **274**, 109681.

Baydar, N.G., Baydar, H. (2013) Phenolic compounds, antiradical activity and antioxidant capacity of oil-bearing rose (*Rosa damascena* Mill.) extracts. *Industrial Crops and Products*, **41**, 375-380.

Bindraban, P.S., Dimkpa, C.O., Pandey, R. (2020) Exploring phosphorus fertilizers and fertilization strategies for improved human and environmental health. *Biology and Fertility of Soils*, **56**, 299–317.

Bradford, M.M. (1976) A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*, **72**, 248-254.

British Pharmacopea (1963) "*Determination of Volatile Oil in Drugs*". Published by Pharmaceutical Press. London. W.C.I.

Butusov, M., Jernelöv, A. (2013) Phosphorus in the organic life: cells, tissues, organisms. In: "*Phosphorus: An Element That Could Have Been Called Lucifer*", Butusov, M., Jernelöv, A. (Eds.), pp. 13-17. Springer Briefs in Environmental Science 9. Springer, New York,, http://dx.doi.org/10.1007/978-1-4614-6803-5 2.

Calatayud, A., Roca, D., Gorbe, E., Martinez, P.F. (2007) Light acclimation in rose (*Rosa hybrida* cv. Grand Gala) leaves after pruning: effects on chlorophyll *a* fluorescence, nitrate reductage, ammonium and carbohydrates. *Scientia Horticulturae*, **111**, 152-159.

Calatayud, A., Roca, D., Gorbe, E., Martinez, P.F. (2008) Physiological effects of pruning in rose plants cv. Grand Gala. *Scientia Horticulturae*, **116**(1), 73-79.

Chesney, P. (2008) Nitrogen and fine root length dynamics in a tropical agroforestry system with periodically pruned *Erythrina poeppigiana*. *Agroforestry Systems*, **72**, 149-159.

Chesney, P., Vasquez, N. (2007) Dynamics of non-structural carbohydrate reserves in pruned *Erythrina poeppigiana* and *Gliricidia sepium* trees. *Agroforestry Systems*, **69**, 89-105.

Chimonidou, D.P., Bodson, M., Verhoyen, M.N. (2000) Correlation between internal and external stages of rose development. *Acta Horticulturae*, **515**, 233-244.

Danyaie, A., Tabaei-Aghdaei, S.R., Jafari, A.A., Matinizadeh, M., Mousavi, A. (2011) Additive main effect and multiplicative interaction analysis of flower yield invarious *Rosa damascena* Mill. genotypes across 8 environments in Iran. *Journal of Food, Agriculture and Environment*, **9**(2), 464-468.

Dubois, M., Gilles, K.A., Hamilton, J.K., Roberts, P.A., Smith, F. (1956) Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, **28**, 350-356.

Garcia, I.S., Souza, A., Barbedo, C.J., Dietrich, S.M.C.E., Figueiredo-Ribeiro, R.C.L. (2006) Changes in soluble carbohydrates during storage of *Caesalpinia echinata* Lam. (Brazilwood) seeds, an endangeredleguminous tree from the brazilian atlantic forest. *Brazilian Journal of Biology*, **66**(2B), 739-745

Gibson, M. (1984) Growing Roses. Beckenham: Croom Helm Ltd.

Güçdemir, İ.H. (2006) Türkiye Gübre ve Gübreleme Rehberi, 5. Baskı T.C. Tarım ve Köy işleri Bakanlığı, Tarımsal Araştırma Genel Müdürlüğü, Ankara.

Hassan, F.A.S., Ali, E.F. (2013) A comparative study between traditional mineral nutrition and alternative sources on anise plant. *European Journal of Scientific Research*, **106**(2), 201-212.

Hassan, F.A.S, Ali, E.F.. Mahfouz, S.A. (2012) Comparison between different fertilization sources, irrigation frequency and their combinations on the growth and yield of coriander plant. *Australian Journal of Basic and Applied Sciences*, **6**(3), 600-

615.

Hassan, F., Ali, E., Alamer, K. (2018) Exogenous application of polyamines alleviates water stress-induced oxidative stress of *Rosa damascena* Miller var. *trigintipetala* Dieck. *South African Journal of Botany,* **116**, 96-102.

Hassan, F., Al-Yasi, H., Ali, E.F., Alamer, K., Hessini, K., Attia, H., El-Shazly, S. (2021) Mitigation of salt stress effects by moringa leaf extract or salicylic acid through motivating antioxidant machinery in damask rose. *Canadian Journal of Plant Science,* **101**(2). https://doi.org/10.1139/CJPS-2020-0127

Hassanein, A.M.A. (2010) Improved quality and quantity of winter flowering in rose (*Rosa spp*.) by controlling the timing and type of pruning applied in autumn. *World Journal of Agricultural Sciences,* **6**, 260-267.

Heidari, S., Azizi, M., Soltani, F., Hadian, J. (2014) Foliar application of $Ca(NO_3)_2$ and KNO_3 affects growth, essential oil content, and oil composition of French tarragon. *Industrial Crops and Products,* **62**, 526–532.

Hossain, A.B.M.S., Amru, N.B., Normaniza, O. (2007) Postharvest quality, vase life and photosynthetic yield (chlorophyll fluorescence) of *Bougainvillea* flower by applying ethanol. *Australian Journal of Basic and Applied Sciences,* **1**, 733-740.

Hossain, A.B.M.S., Fusao, M. (2008) Determination of abscisic acid hormone (ABA), mineral content and distribution pattern of 13C photoassimilates in barkringed young peach trees. *Maejo International Journal of Science and Technology*, **2**, 274-284.

Huang, W., Zhao, X., Liang, N., He, L., Yu, L., Zhan. Y. (2019) Phosphorus deficiency promotes the lateral root growth of *Fraxinus mandshurica* seedlings. *Journal of Plant Nutrition and Soil Science*, **182**(4). DOI:10.1002/jpln.201800465

Kahil, A.A., Hassan, F.A.S., Ali, E.F. (2017) Influence of bio-fertilizers on growth, yield and anthocyanin content of *Hibiscus sabdariffa* l. plant under Taif region conditions. *Annual Research & Review in Biology*, **17**(1), 1-15.

Karl, D.M. (2014) Microbially mediated transformations of phosphorus in the sea: New views of an old cycle. *Annual Review of Marine Science*, **6**, 279–337.

Khoshgoftarmanesh, A.H., Khademi H., Hosseinin F., Aghajani R. (2008) Influence of additional micronutrient supply on growth, nutritional status and flower quality of three rose cultivars in a soilless culture. *Journal of Plant Nutrition*, **31**, 1543-1554.

Kumar, R., Sharma, S., Sood, S., Agnihotri, V.K. (2013) Agronomic interventions for the improvement of essential oil content and composition of damask rose (*Rosa damascena* Mill.) under western Himalayas. *Industrial Crops and Products*, **48**, 171-177.

Li, K.T., Lakso, A.N., Piccioni, R., Robinson, T. (2003) Summer pruning reduces wholecanopy carbon fixation and transpiration in apple trees. *Journal of Horticultural Science and Biotechnology*, **78**, 749-754.

Lin, S., Litaker, R.W., Sunda, W. (2015) Phosphorus physiological ecology and molecular mechanisms in marine phytoplankton. *Journal of Phycology*, **52**, 10–36.

Loera-Quezadaa, M.M., Leyva-Gonzálezb, Damar López-Arredondob, M.A., Herrera-Estrellaa, L. (2015) Phosphite cannot be used as a phosphorus source but is non-toxic formicroalgae. *Plant Science*, **231**, 124-130.

López-Arredondo, D.L., Leyva-González, M.A., González-Morales, S.I., López-Bucio, J., Herrera-Estrella, L. (2014) Phosphate nutrition: Improving low-phosphate tolerance in crops. *Annual Review of Plant Biology,* **65**, 95-123.

Malhotra, R., Kumar, R. (2000) Effect of pruning height, shading and polythene covering on growth and flower production of rose cv. Raktagandha. *Journal of Ornamental Horticulture*, **3**(2), 94-99.

Medhurst, J.L., Pinkard, E.A., Beadle, C.L., Worledge, D. (2006) Photosynthetic capacity increases in *Acacia melanoxylon* following form pruning in a two-species plantation. *Forest Ecology and Management,* **233**, 250-259.

Mohamadi, M., Mostafavi, A., Shamspur, T. (2011) Effect of storage on essential oilcontent and composition of *Rosa damascena* petals under different conditions. *Journal of Essential Oil-Bearing Plants,* **14**(4), 430-441.

Naik, S.K. Maurya, S., Kumar, R., Sadhna, K., Gagrai, S., Das, B., Kumar, S., Bhatt, B.P. (2013) Inorganic

phosphate solubilization by phosphate solubilizing fungi isolated from acidic soils. *African Journal of. Microbiology Research,* **7**, 4310–4316.

Nelson, D.W., Sommers, L.E. (1973) Determination of total nitrogen in plant material. *Agronomy Journal,* **65**, 109-112.

Pal, P.K. (2013) Evaluation, genetic diversity, recent development of distillation method, challenges and opportunities of *Rosa damascene*: A review. *Journal of Essential Oil-Bearing Plants,* **16**, 1-10. doi: 10.1080/0972060X.2013.764176

Pal, P.K., Singh, R.D. (2013) Understanding crop-ecology and agronomy of *Rosa damascena* Mill for higher productivity. *Australian Journal of Crop Science,* **7**(2), 196-205.

Pal, P.K., Mahajan, M. (2017) Pruning System and Foliar Application of $MgSO_4$ Alter Yield and Secondary Metabolite Profile of *Rosa damascena* under Rainfed Acidic Conditions. *Frontiers in Plant Science*, **8**, 507.

Pal, P.K., Agnihotri, V.K., Gopichand, Singh, R.D. (2014) Impact of level and timing of pruning on flower yield and secondary metabolites profile of *Rosa damascena* under western Himalayan region. *Industrial Crops and Products*, **52**, 219-227.

Prasad, R., Shivay, Y.S., Kumar, D., Sharma, S.N. (2006) "*Learning by Doing Exercise in Soil Fertility-Practical Manual for Soil Fertility*". New Delhi: Indian Agricultural Research Institute.

Ramaekers, L., Remans, R., Rao, I.M., Blair, M.W., Vanderleyden, J. (2010) Strategies for improving phosphorus acquisition efficiency of crop plants. *Field Crops Research*, **117**, 169-176.

Ruiz, J., Romero, L. (2002) Relationship between potassium fertilization and nitrate assimilation in leaves and fruits of cucumber (*Cucumis sativus*) plants. *Annals of Applied Biology*, **140**, 241-245.

Rusanov, K., Kovacheva, N., Vosman, B., Zhang, L., Rajapakse, S., Atanassov, A., et al. (2005) Microsatellite analysis of *Rosa damascena* Mill. accessions reveals genetic similarity between genotypes used for rose oil production and old Damask rose varieties. *Theoretical and Applied Genetics*, **111**, 804-809.

Sadasivam S., Manickam, A. (1992) "*Biochemical Methods for Agriculture Sciences*", pp. 181-185. Wiley Eastern limited.

Saffari, V.R., Khalighi, A., Lesani, H., Babalar, M., Obermaier, J.F. (2004) Effects of different plant growth regulators and time of pruning on yield components of *Rosa damascena* Mill. *International Journal of Agriculture and Biology*, **11**, 1560-8530.

Saifuddin, M., Hossain, A.B.M.S., Normaniza, O. (2010) Impacts of shading on flower formation and longevity, leaf chlorophyll and growth of *Bougainville glabra*. *Asian Journal of Plant Sciences*, **9**, 20-27.

Sarkka, L., Erikson, C. (2003) Effects of bending and harvesting height combinations on cut rose yield in a dense plantation with high intensity lighting. *Scientia Horticulturae,* **98**, 433-447.

Schleuss, P.M., Widdig, M., Heintz-Buschart, A., Kirkman, K., Spohn, M. (2020) Interactions of nitrogen and phosphorus cycling promote P acquisition and explain synergistic plant-growth responses. *Ecology*, **101**(5), e03003

Secco, D., Whelan, J., Rouached, H., Lister. R. (2017) Nutrient stress-induced chromatin changes in plants. *Current Opinion in Plant Biology*, **39**, 1-7.

Senapati, S.K., Rout, G.R. (2008) Study of culture conditions for improved micropropagatioof hybrid rose. *Horticultural Science - Prague*, **35**, 27-34.

Shahbazi, F., Nematollahi, A. (2019) Influences of phosphorus and foliar iron fertilization rate on the quality parameters of whole wheat grain. *Food Science & Nutrition,* **7**, 442–448.

Shahbazi, F., Sharafi, R., Moomevandi, S.J., Daneshvar, M. (2014) Mechanical damage to wheat seeds as affected by phosphorus and iron fertilization rate. *Quality Assurance and Safety of Crops and Foods,* **7**, 385-391.

Sharma, S., Kumar, V., Tripathi, R.B. (2011) Isolation of phosphate solubilizing microorganism (PSMs) from soil. *Journal of Microbiology and Biotechnology Research,* **1**, 90–95.

Shawl, A.S., Adams, R. (2009) Rose oil in Kashmiri India. *Perfumer & Flavorist*, **34**, 22-25.

Singh, D.V., Ram, M. (1987) Effect of spacing, extent

of pruning, growth hormone and nutrients on flower yield of essential oil bearing rose (*Rosa damascena*) in subtropical India. *Acta Horticulturae*, **208**, 83-86.

Steel, R.G.D., Torrie, J.H. (1960) "*Principles and Procedures of Statistics with Special Reference to the Biological Sciences*". McGraw-Hill Book Company, Inc., New York.

Tabaei-Aghdaei, S.R., Hosseini Monfared, H., Fahimi, H., Ebrahimzadeh, H., Jebelly, M., Naghavi, M.R., Babaei, A. (2006) Genetic variation analysis of different population of *Rosa damascena* Mill in NW, Iran using RAPD markers. *Iranian Journal of Botany*, **12**, 121-127.

Taiz, L., Zeiger, E. (2010) "*Plant Physiology*" (5th ed). Sunderland, MA: Sinauer.

Van Noordwijk, M., Purnomosidhi, P. (1995) Root architecture in relation to tree-soil crop interactions and shoot pruning in agroforestry. *Agroforestry Systems*, **30**, 161-173.

Weatherley, P.E. (1950) Studies in the water relations of the cotton plant.1.The field measurements of water deficit in leaves. *New Phytology,* **49**, 8.

Wood, A.J., Roger, J. (2000) A simple and non-destructive technique for measuring plant growth and development. *American Biology Teacher,* **62**, 215-217.

Yemm, E., Cocking, E., Ricketts, R. (1955) The determination of amino-acids with ninhydrin. *Analyst*, **80**, 209-214.

Younis, A., Atif, R., Salman, A., Muhammad, A., Usman, T., Fariha, J., Muhammad N., Mansoor, H. (2013) Effect of different pruning dates on growth and flowering of *Rosa centifolia*. *Pakistan Journal of Agricultural Sciences*, **50**, 605-609.

تأثير نظام التقليم والسماد الفوسفاتي على النمو والإنتاجية لنباتات الورد الطائفي

عصمت فاروق علي احمد[1، 2]، حاتم بن معتوق الياسي[1]، فهمي عبدالرحمن صادق حسن [1، 3]، خالد حسن آل عامر [1، 4]، كمال الرزقي حسيني[1]، هنيدة عطية [1، 5]، سمير احمد محمد الشاذلي [6، 7]

[1] قسم الأحياء - كلية العلوم - جامعة الطائف - ص.ب.11099 - الطائف 21944 - المملكة العربية السعودية، [2]قسم البساتين (زراعة الزهور) - كلية الزراعة - جامعة أسيوط - أسيوط - مصر، [3] قسم البساتين - كلية الزراعة - جامعة طنطا - طنطا - مصر، [4] قسم الأحياء - كلية العلوم والآداب برابغ - جامعة الملك عبد العزيز - جدة - المملكة العربية السعودية، [5] مركز التكنولوجيا الحيوية ببرج السدرية- جامعة تونس المنار - تونس، [6] قسم التكنولوجيا الحيوية - كلية العلوم - جامعة الطائف - الطائف - المملكة العربية السعودية، [7] قسم الكيمياء الحيوية- كلية الطب البيطري - جامعة كفر الشيخ- كفر الشيخ - مصر.

الحصول على أعلى محصول أزهار محتوي على اعلى جودة من الزيت الطيار لنباتات الورد الطائفي من خلال الممارسات الزراعية الجيدة هي واحدة من اهم تحديات النتاج الزيت العطري. على الرغم من الدور الرئيسي للتقليم والأسمدة الفوسفاتية والتي تحسن بشدة إنتاجية الزهور، وكذلك لتأثيراتها على النمو، ومحصول الزيت الطيار، فانه لا تزال لا توجد دراسات عن استجابة العمليات الفسيولوجية والكيميائية الحيوية للورد الطائفي فيما يخص تلك المعاملات. في هذه التجربة، تم دراسة مستويان من التقليم وهما التقليم على ارتفاعات 80 و100 سم من مستوى الأرض وثلاث معدلات من السماد الفوسفاتي هي 0، 15، 30 كجم P_2O_5 لكل هكتار، على التوالي). وجد من نتائج الدراسة ان أطول النباتات تم الحصول عليها من المعاملة المشتركة بين التقليم على ارتفاع 100 سم واضافه 30 كيلوجرام للهكتار من السماد الفوسفاتي. بينما اضافه نفس المستوي من السماد الفوسفاتي والتقليم على ارتفاع 80 سم من مستوي سطح التربة نتج عنه أكبر عدد من الفروع الحديثة لكل جورة، اعلى مكونات لإنتاج الازهار وأكبر محتوى من الزيت واعلى محتوى مائي للأوراق ومحتوى الكلوروفيل والمحتوى الكلي للسكر وكذلك محتويات الأوراق من عناصر النيتروجين والفوسفور والبوتاسيوم بالمقارنة بباقي المعاملات. زاد محصول الازهار بنسبه 23.52% عندما تم تقليم النباتات على ارتفاع 80 سم وتسميدها ب 30 كيلوجرام سماد فوسفاتي للهكتار بالمقارنة بالتقليم على ارتفاع 100 سم بدون اضافه اسمدة فوسفاتية. تقليل مستوي التقليم وزيادة اضافه السماد الفوسفاتي ادى إلى زيادة محتوى البروتين بينما قلل محتوى الأحماض الأمينية الحرة. بشكل مجمل، للحصول على أعلى محصول من الأزهار وأكبر إنتاجية للزيت الطيار، فانه يوصي بتقليم نباتات الورد الطائفي على ارتفاع 80 سم من مستوى سطح التربة والتسميد بمعدل 30 كيلوجرام من السماد الفوسفاتي للهكتار.