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INFLUENCE OF AIR TEMPERATURE AND SOIL MOISTURE ON GROWTH AND CHEMICAL COMPOSITION OF GERANIUM PLANTS

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Abstract

This study was carried out, to examine the effect of different air temperature (15 and 27 ± 3°C) with three levels of soil moisture (70%, 80%and 90% of field capacity) on production of Geranium (*Pelargonium graveolens* L) plants. The obtained results showed that, plant growth i.e., plant height (cm), branches number, fresh and dry weight of shoots were decreased with geranium plants acclimatized under conditions of low air temperature and high soil moisture. Physiological characters like chlorophyll a, chlorophyll b, total chlorophyll and total carotenoids contents indicated the effect of 27°C temperature with soil moisture70% and increased in geranium plants than in those acclimatized under 15°C temperature and different % of soil moisture.

The extracted essential oils were analyzed using GC/MS. The major compounds in essential oils of geranium were geraniol (36%) and citronellol (18.%) at an air temperature 27 ± 3°C and levels of soil moisture (70%) compared with geraniol (17%) and citronellol (8%) at an air temperature 15 ± 3°C) at a soil moisture level of 70%.

Key words: Geranium plants, Chlorophyll contents, Soil moisture, Air temperature, Essential oil.

Introduction

The *Pelargonium* genus family Geraniaceae contains about 280 herbaceous, shrub, and sub shrub species, including both perennials and annuals that originated from southern Africa (Bakker *et al*., 2004). Geranium plant (*Pelargonium graveolens* L.) is used as ornamental plant and reported to have several folkloric medicinal applications. *Pelargonium graveolens* is considered as one of the most favourite flowering plant that is used as annual bedding plant. Also, they are cultured in sunny locations as house plants. One of the important fragrant of Pelargonium is rose geranium which is used as a source of extraction of geranium essential oils. Geranium plant is a native to South Africa and many countries like Egypt, Algeria, Morocco, Spain, China, and, France use it for the production of its essential oil (Lis-Balchin *et al.*, 1998; Rana *et al.*, 2002).

Environmental stresses are detrimental to the growth of geranium plants. Salinity, drought, temperature, flooding, and heavy metal contamination, are abiotic factors that affect the growth of geranium plants to the range that a reduction in yield is obtained. Ahmad *et al*., (2016) and Hashem *et al*., (2016) illustrated that abiotic stresses have a harmful effect on plant growth through reducing water uptake and hence alter plant physiological and biochemical processes. Also the environmental factors like physical-chemical characteristics of the soil, moisture, temperature, can reduce the production of essential oils in several plants (Sangwan *et al*., 2001). Recently, many abiotic factors were studied to detect their affects on the production of volatile compounds in medicinal and aromatic species (Eiasu *et al.*, 2009; Rao, 2002). Temperature and soil moisture are expected to be the two critical factors that affect on geranium production and essential oil contents. Very high temperatures decreases soil moisture hence leads to moisture stress in the plant (Andrew *et al.*, 2010; Lobell *et al.*, 2013).

Both of foliage and flowers of rose geranium contain special glands that are known as the main source of essential oils. Plant parts contain essential oils must be cut in the morning in sunny and dry weather then distillation begins after a few hours drying of cut parts. The essential oils of rose geranium are composed chiefly of citronellol, geraniol, citronellyl formate, linalool, and several other compounds (Rao, 2009). Geranium oil is widely used in perfumery and in cosmetics because of its stability and blends well with other fragrances (Boukhris *et al*., 2013). The geranium essential oil play an important role in industrial field since it used in manufacture of perfume, cosmetic, soap, aromatherapy, and food industries (Ali *et al.*, 2015; Motsa *et al*., 2006). Also the oil of rose geranium is used as a flavoring agent in many food categories, alcoholic beverages and soft drinks (Sedibe & Allemann, 2012). It is also used in popular medicines against dysentery, diarrhea, colds, and lung infections (Zore *et al.*, 2011). The essential oil extracts of geranium can be used as a potential source of natural antioxidants (Boukhris *et al.*, 2013; Singh *et al*., 2009).

Plant species like *Geranium schiedeanum* contains polyphenolic compounds, especially tannins. Recently many research workers advocated that tannins recognized with their antioxidant properties (Gayosso-De-Lucio *et al*., 2014; Ibrahim *et al*., 2017).

The aim of this investigation was to acclimatize geranium plants using controlled temperature and soil moisture to examine geranium leaf physiological and chemical changes associated with different temperature and soil moisture regimes.

Materials and Methods

These experiments were carried out at Taif University during years 2016 and 2017. This study was designed to investigate the growth of *Pelargonium graveolens* plants cultured in pots containing sand and peat moss under different temperature and soil moisture conditions after 4 and 8 months, to select the best growth and then the leaves were taken to determine the following physiological and chemical composition under the study of number of leaves, number of shoot branches, length of plants, chlorophyll a, chlorophyll b, carotenoids and chemical composition percentages.

Experiment design: Geranium plants were cultured under different air temperatures at 15±3 and 27±3°C with three levels of soil moisture (70%, 80%and 90% of field capacity FC). The treatments were arranged in a Randomized complete Block Design with five replicates.

Measurement of physiological characteristics: Geranium plants were dried at 110°C in the oven for 4 days and then dry weights were measured. Chlorophyll contents were measured by the methods of (Shabala *et al*., 1998). Total carotenoids were determined according to (Lichtenthaler, 1987). Chlorophyll and carotenoid concentrations were calculated and represented in mg/g.

Extraction method of essential oil: Fresh leaves were selected to hydro distillation for 2 h. The essential oils were extracted with dichloromethane. Essential oil samples used for the GC/MS analysis were dissolved in Dichloromethane according to (Ibrahim *et al*., 2017).

Gas chromatography of geranium essential oil: After preparing of geranium essential oils sampling, the analyses were performed using Agilent 19091S gas chromatography (GC). GC-MS analysis was performed with a fused silica HP-1 capillary column (30×0.25 cm id; 0.50 µm film thickness), and coupled to an Agilent Mass Selective Detector MSD 5973. Temperature was increased to 100°C for 0.5 min, then increased to 280°C at a rate of 4°C/min, and maintained for 20 min. The other parameters were: injection temperature, 280°C; EI, 70Ev; Carrier gas, He at 1 ml/min; injection volume, 1 µl; split ratio, 1:60; and mass range, m/z 40−600.

Statistical analysis: Each experiment was conducted in triplicate (n = 3). Results were shown as mean ± standard error. Experimental data was analyzed using statistical software SPSS.

Results

Effect of different air temperatures and % soil moisture on number of shoot branches and plant height: Results indicated that there were significant (p at the most 0.05) differences between the effect of different air temperatures and % of soil humidity on all growth characters for geranium plants.

Effect of different air temperatures and % of soil moisture on number of shoot branches (Fig. 1) and plants height (Fig. 2) were described. Results showed that as the temperature increases, the number of shoot branches and plant height increases. The maximum value of number of shoot branches, and plant height were after 8months at 27°C, while the lowest value of both of them compared with other treatments were after 4 months at 15°C. On the other hand, (Fig. 1) and (Fig. 2) indicated that the increase of % soil moisture affected negatively on number of shoot branches and height of geranium plants.

Effect of different air temperature and % soil moisture on number of leaves and leaf area of geranium plants: (Figs. 3 and 4) showed that increase % of soil moisture significantly reduced ($p<0.05$) both number of leaves and leaves area. Also data showed that increasing temperature condition especially after 8 months induced increase in number of leaves and also leaf area. Since, it increased from 32, 25 at 15°C to 49, 43 at 27°C respectively. The lowest values of number of leaves and leaf area compared with other treatments were detected after 4 months at 15°C and 90% (of FC) soil moisture while the highest values of number of leaves and leaf area were detected after 8 months at 27°C and 70% (FC) soil moisture.

Effect of different air temperature and % soil moisture on fresh and dry weight of geranium plants: Regarding to of fresh weight data, (Fig. 5) clarified that fresh weight of the plant increased as temperatre increased while increase soil moisture decreased fresh weight of geranium plants. The same results showed with dry weight of geranium plants (Fig. 6).

Since the highest values for all growth characters (plant height, number of leaves and shoot branches and leaf area) were observed after 8 months at 27°C and 70% soil moisture, similarly the highest values for both fresh and dry weights were also obtained at that condition.

Effect of different air temperature and % soil moisture on pigment contents of geranium plants: (Table 1) showed that plants grown under 15°C air temperature and 70% (FW) soil moisture produced the lowest value (0.54 and 0.05 mg/gm FW) for chlorophyll a and chlorophyll b respectively. While plants grown under 27°C air temperatures and 70% soil moisture showed increase in chlorophyll a (0.722 mg/gm FW) and chlorophyll b (0.10mg/gm FW). Also data showed highest value of carotenoids content with plants under exposure to temperature at rate 27°C with 70% (FW) soil moisture and reached 0.35 mg/gm FW.

Gas chromatography analysis of essential oil contents in geranium plant tissues: The total number of peaks was 21 and 25 for the oil samples obtained from the leaves of *geranium* plants under 30 and 15°C air temperatures respectively as shown in (Fig. 7).

We identified geraniol, citronellol and citronellyl formate as the major chemical components of *Geranium* plant. The corresponding peaks obtained in the different samples indicated that plants grown under 27°C air temperature and 70 % (FW) soil moisture represented the highest content of geraniol (peak 13), citronellol (peak 9) and citronellyl formate (peak 15) (36%, 18%, and 9% respectively) (Fig. 7a). While geraniol (peak 12), citronellol (peak 7) and citronellyl formate (peak 15) represented (17%, 8% and 10% respectively) as showed in (Fig. 7b).

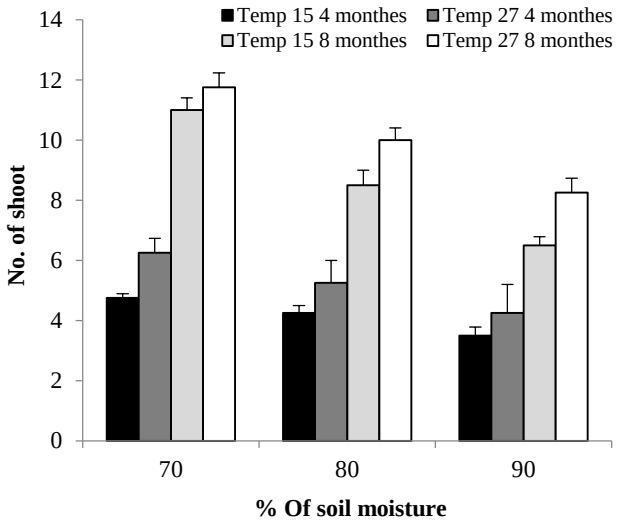

Fig. 1. Effect of different air temperature and % soil moisture on number of shoot branches for geranium plants.

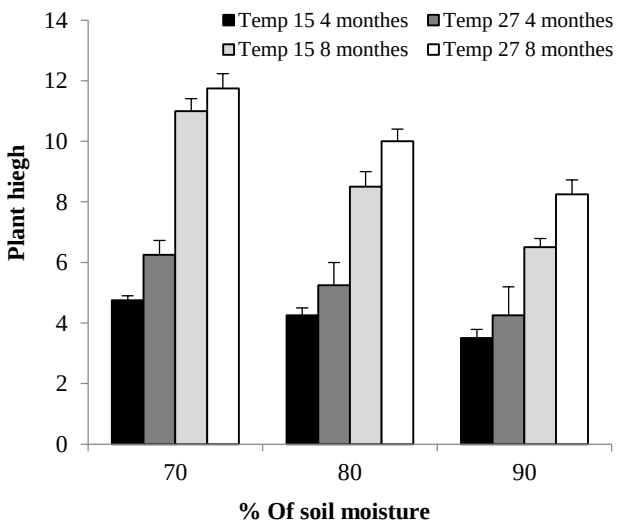

Fig. 2. Effect of different air temperature and % of soil moisture on plant height.

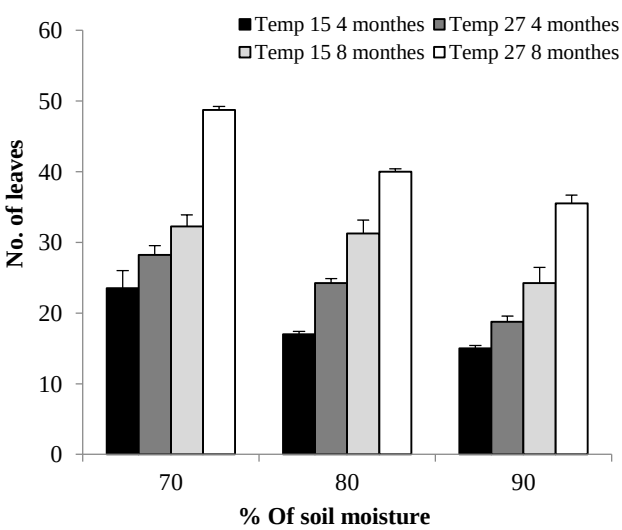

Fig. 3. Effect of different air temperature and soil moisture % on number of leaves.

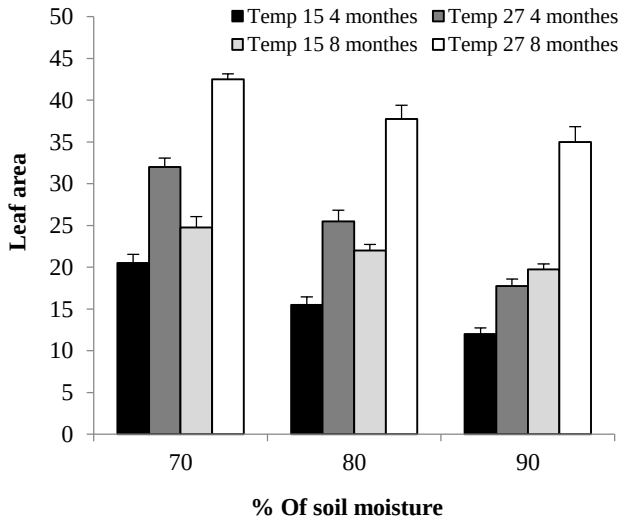

Fig. 4. Effect of different air temperature and soil moisture %on leaf area.

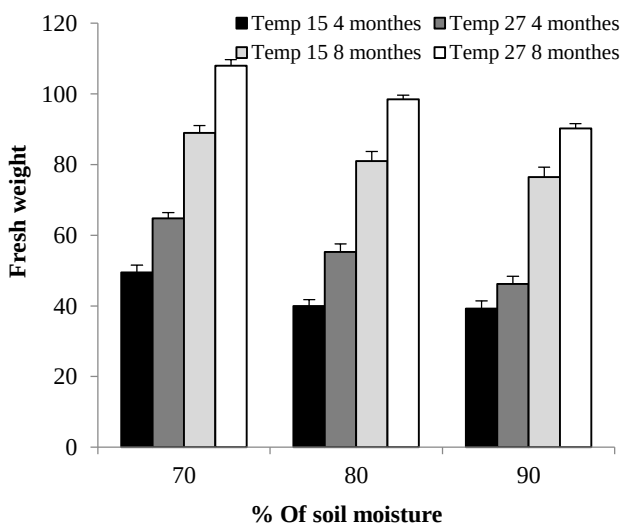

Fig. 5. Effect of different air temperature and soil moisture % on fresh weight.

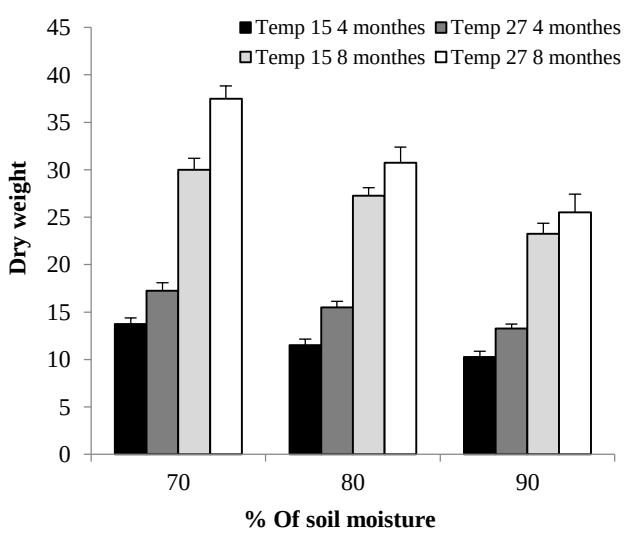

Fig. 6. Effect of different air temperature and soil moisture % on dry weight.

Table 1. Effect of different air temperature and 70 % soil moisture on pigments of Geranium plants.

Temperature	Chlorophyll A	Chlorophyll B	Total Chlorophyll	Carotenoids
15ºC	0.54	0.05	0.59	0.21
27ºC	0.722	0.10	0.82	0.35

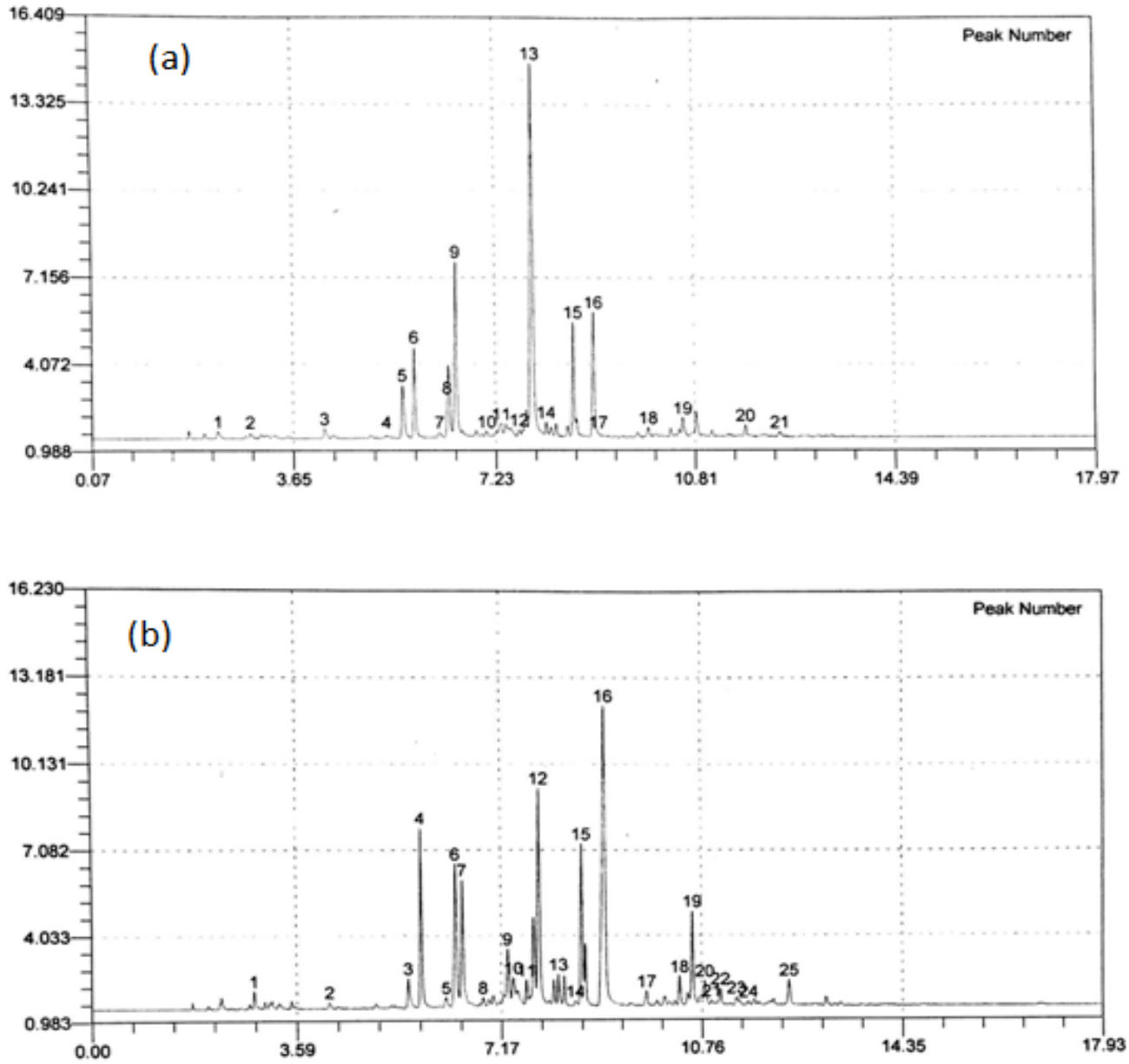

Fig. 7. GC-MS chromatogram analysis of essential oil contents in *Geranium* plant tissues grown under 30°C air temperature (a) and 15°C air temperature (b) and 70% soil moisture content.

Discussion

The target of the present study was to investigate the effect of air temperature and soil moisture on the physiological characteristics and chemical components of geranium plants.

At the beginning the results showed that leaf area and number of leaves were increased as the temperature increased at 27°C, also Chlorophyll contents were increased at the same condition. The same results were obtained by (Dhir *et al*., 2013), Data showed lowest value of carotenoids content with plants under exposure to the temperature at rate 15°C., and reached 0.21 mg/gm fw, these result agreement (Ortiz *et al*., 2016). Results of this study may be ascribed to the evidence to confirm that geranium plants show production in the experimental population in response to temperature availability during seed maturation and also with low soil moisture. It should be pointed out that high temperature and low soil moisture necessarily required to greater productivity in geranium plants and these results are in good agreement with results obtained by Hatfield & Prueger (2015). Rose geranium, *Pelargonium graveolens* L. is one of the many fragrant species of Pelargonium used as a source of geranium oil (Boukhris *et al*., 2012; Verma *et al*., 2016).

In this experiment, the effect of temperature and soil moisture on physiological properties and the chemical composition of plants were determined. Chlorophyll A, chlorophyll B, total carotenoids, essential oil contents and physiological character showed different changes in all contents affected by temperature and soil moisture.

Gas chromatography (GC) analysis of the oil samples showed that essential oil content was found to be higher during high temperature and lower soil moisture regime. This may be due to better response of plants to higher temperature and increased metabolic activities, resulting in the vigorous growth of the plants. The same results are reported by (Shahi & Singh, 1981; Verma *et al.,* 2013). The major essential oils represented in this study were geraniol, citronellol and citronellyl formate. This is in agreement with previous reports (Boukhris *et al.,* 2012; Rao *et al.*, 2002) which demonstrated that chemical composition of rose geranium oils are characterized by citronellol as a major and most important component.

Conclusions

In conclusion, this study demonstrates differences in production and chemical composition of geranium plants in response to temperature and soil moisture during its growth. Given that differences in productivity parameters and chemical composition, studies including more experiments are needed. Available evidence suggests that the factors such as temperature and soil moisture may act to explain the increasing in growth of geranium plants and hence increased essential oil content of geranium.

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