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Viola odorata (Sweet Violet) Plant's Growth and Chemical Components are affected by Irrigation Intervals and Natural Anti-Transpiration

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ABSTRACT

This study was carried out to investigate the effect of irrigation intervals (every 1, 2 and 3 days) and some natural anti-transpiration (humic acid, $CaCO_3$ and $MgCO_3$) as well as their interactions on growth, flowering, concrete yield, total carbohydrates % , total chlorophylls % and chemical constituents of *Viola odorata* obtained results showed that, the highest values of vegetative growth parameters (herb fresh and dry weight g/plant and flowers fresh and dry weight g/plant) as well total carbohydrates % , total chlorophylls % and chemical composition (nitrogen, phosphorus and potassium percentages/ plant) could be achieved by irrigated every one day combined with spraying plants with humic acid at 2kg/feddan. However, the highest value of leaves and flowers concrete % obtained under irrigated every two days interval applied to plants combined with spraying plants with humic acid at 2kg/feddan. Also the same treatment gave the highest value of main constituents of the volatile oil leaves and flowers which were butyl-2 ethylhexyl phthalate followed by 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy) butan-2-ol.

Keywords: *Viola odorata*, irrigation intervals, anti-transpiration, growth, concrete yield, volatile oil constituents.

1. Introduction

Sweet Violet plant (*Viola odorata* L.) a perennial plant belonging to the Violaceae family, it grows wild in shady, moist, calcareous places. It is cultivated in gardens as an ornamental plant and for medical purposes and is cultivated in large areas to obtain aromatic leaves or flowers in silt and sandy lands. Its cultivation is spread in southern France, Egypt, Algeria, Southeast Asia and Bulgaria. It is planted in Egypt in the ELGharbia, ELNubaria, and Al-Menoufia governorates. There are many types of violets, but the most important are two types that are used medicinally, the first aromatic violets, and the second tri-colored violets as an ornamental plant. Also the plant with a running stem above the surface of the soil, with vertical branches bearing dark green, heart-shaped leaves, with a rounded top and full edges, sometimes smooth. The flowers are single or double axillary, violet, white, crimson, or whitish yellow, with a distinctive aromatic smell. The leaves are the most important economic plant part used as a source for obtaining violet oil. Moreover, the essential oil is collected and extracted with organic solvents (hexane or petroleum ether) at a rate of 0.1%, and the flowers are also used medically as a natural sedative because they contain an aromatic oil that differs in composition from the oil of the leaves, but it was not relied on as a source of oil because its percentage is very low and it is used fresh or dried (Akhbari *et al.,* 2012):

Essential oil of violet plant contains the following chemical compounds: phenyl butanone, linalool, benzyl alcohol, α-cadinol, globulol and viridiflorol. (Karioti *et al.,* 2011). It is used in the manufacture of cosmetics and perfumes. Oil and flowers are used as a natural tranquilizer for nerves and helps sleep, essential oil is used in European folk medicine to treat cancerous diseases, especially breast and lung cancer, and to treat bronchitis, respiratory infections, coughs, asthma, diaphoretic, diuretic and is used to treat mouth and throat infections. The flowers are edible. So, the French are known to be the first to use violets in the manufacture of sweets, drinks and teas. Also, it is used as food

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additives, for example, in salads, jelly, and desserts. Boiled roots are used as a laxative. In addition, the tea made from a whole plant is used to treat digestive disorders. It is also a cure for headaches, migraines, insomnia, and body pain relief. It is used externally as an ointment to reduce swelling and treat bacterial skin eczema (Bown, 1995).

Experiments have shown that irrigation intervals and spraying with anti-transpiration on some crops has a positive effect in improving the contract and raising the productivity of these crops. These results are in harmony with those obtained by Afify *et al.,* (2001) on roselle and Eid and Abouliela, (2006) on croton. In terms of mechanical performance, anti-transpiration is divided into three types: the first is materials that reflect sunlight, the second works to close the stomata, and the third works by creating a layer on the surface of the leaves. Many of the materials used in these experiments are magnesium carbonate which is known as (Mansia), as well as calcium carbonate and humic acid, Song *et al.,* (2011) on *Rosa hybrida* L, indicated that anti-transpiration agents work on partial closure of stomata by forming a layer on the surface of the leaf, reducing water loss through transpiration (Shanan and Shalaby, 2011) on vase life of Monster deliciosa leaves. When spraying anti-transpiration agents at a concentration of 1, 4 and 8% on the leaves of the *Monstera delicious* plant, it reduced the loss of water and proteolytic enzymes.

Humic acid contains many organic compounds, amino acids and nutrients, especially potassium, which plays an important role in many processes within the plant, including regulating the work of stomata, as the accumulation of potassium in the guard cells serves as the driving forces for the process of opening and closing stomata, and this process is related to the level of potassium in the cell and sugars. This process prevent water evaporation, thereby increases the relative water content of leaf under drought conditions (Mijani *et al.,* 2015) on hibiscus (*Hibiscus sabdarifa*). Humic acid also increases the permeability of cell membranes and nutrient absorption, which leads to an increase in photosynthesis and the formation of carbohydrates and proteins, which are the basic building blocks of enzymes and chromosomes, and thus reduces acids. Decomposing amino acids, including proline, by reducing stress on the plant, because proline doubles to 12.5 times in plants exposed to stress.

Calcium carbonate ($CaCO_3$), it is in the form of a white powder to make a layer on the surface of the leaves (Khater, 2010) on *Nicotiana gluca*. Magnesium carbonate ($MgCO_3$), it is a white salt that does not dissolve in water and also works as a layer on the surface of the leaves (Shanan and Shalaby, 2011) on vase life of *Monster deliciosa* leaves.

Many sources have indicated that water stress leads to great damage to the plant and a decrease in the yield, the percentage of oil and the active ingredients, and that spraying some organic and chemical compounds such as humic acid and anti-transpiration on the plant would increase the plant's tolerance to stress for drought. So, the aim of the experiment was studying the effect of irrigation and natural anti-transpiration on growth, yield, oil and the active substance in violet plants, and studying the role of these materials as a catalyst for endurance of violet plants for occasions of environmental stress conditions.

2. Material and Methods

The present study was conducted during two successive seasons of 2018/ 2019 and 2019/ 2020 seasons Al-Sadat City, Al-Menoufia Governorate Egypt, on a private farm, on sweet violet (*Viola odorata* Linn.) to investigate the effect of irrigation intervals and some natural anti-transpirationon growth, flowering, concrete oil yield and chemical constituents of *Viola odorata* (Violet) plant. The plants were planted in the permanent land with rhizomes that were previously prepared from a previous crop on 20thSeptember 2019 for the first season and 25th September 2021 in the second one and plants stayed in two consecutive years.

2.1. Plant materials

Rhizomes of violets (*Viola odorata* L.) were obtained from at Al-Sadat City, A private farm dedicated to the production of aromatic plants. The rhizomes are planted at a distance of 30 cm between the holes and 75 cm between the rows of the plant (4 plant/hill) in the whole period of both seasons for only one hour per plant, irrigation intervals (1, 2 and 3 days).

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Table 1: Mechanical and chemical analyses of the soil.

Depth (cm)	pH	EC dS·cm^{-1}	Coarse sand	Silt %	Fine sand	Clay %	Class Texture	
0-30	7.88	0.43	57.05	6.23	30.11	7.66	Sandy	
OM %	Soluble anions (meq/l)				Soluble cations (meq/l)			
	CO_3^{-2}	HCO_3^-	SO_4^{-2}	Cl^-	Ca^{+2}	Mg^{+2}	Na^+	K^+
0.83	-	2.33	0.79	1.49	1.44	0.84	1.88	0.13

Table 2: Chemical analysis of irrigation water.

EC Dc/m	pH	Soluble cations (ppm)				Soluble anions (ppm)			
		Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	SO_4^{--}	Cl^-
0.611	7.83	1.87	1.38	3.06	0.13	-	2.86	1.23	2.35

Both soil and water samples were analyzed in the desert research center laboratories. Chemical Fertilizers: Fertilizers which used were as follow: compost is added at 10 m^3per feddan, in addition to 450 kg of ammonium sulfate + 300 kg of calcium superphosphate + 75 kg of potassium sulfate + magnesium, at the rate of 25 kg per feddan as magnesium sulphate (16%MgO) (Abd El-Wahab, 2002). The source of natural anti-transpiration was as follows. Humic acid obtained from Land, water and Environment Research Institute. Agriculture Research Center. Giza 9 Cairo University Street. $CaCO_3$ and $MgCO_3$obtained from Al-Gomhouria for the trade of medicines, chemicals and medical supplies company-23 El-Sawah St., El-amiriya. Cairo, Egypt.

The treatments were conducted as follows

1- Irrigation treatments

I-1 -Irrigated every 1 day I- 2-Irrigated every 2 days I-3- Irrigated every 3 days

2 - Spraying with natural anti-transpiration

2-1- (AT 0) Control (Spraying with water once, 21 days before cuts).
2-2- (AT 1) (Spraying with humic acid at 2kg/feddan once, 21 days before cuts.
2-3- (AT 2) Spraying with $CaCO_3$ once, 21 days before cuts.
2-4- (AT 3) Spraying with $MgCO_3$ once, 21 days before cuts.

2.2. Data recorded

Vegetative growth parameters

The recorded data included

- Fresh weight of leaves/ plant (g).
- Dry weight of leaves / plant (g).

The Leaves are cut four times periodically for each plant, every two months, starting from the 2nd week of May, thus the fresh weight of leaves/ plant, and dry weight of leaves / plant separately were calculated for the sum of 4 cuts for each plant separately.

Flowering parameters

- Fresh weight of flowers/ plant (g).
- Dry weight of flowers/ plant (g).

The flowers were picked for each plant separately, periodically, approximately every two weeks, starting from the third week of February to the first week of May, and the fresh weight and the dry weight of the flowers for each plant was calculated, then the concrete percentage of the leaves and flowers for each plant was calculated separately at the end of each season and this was repeated in the two seasons.

Plant chemical analysis

Total nitrogen, phosphorus, potassium and total carbohydrates (٪) were determined according to Horneck and Hanson, (1998) and Horneck and Miller, (1998).

Chlorophyll contents (mg/100gm F. W.) were determined according to the method of Sadasivam and Manickam (1996).

Determination of essential oil percentage

Volatile oil concrete extraction with organic solvents

Concrete oil yield % of leaves and flowers were extracted according to Guenther (1961).

Essential oil extraction was determined according to Adams, (2007).

Statistical analysis

Twelve treatments were arranged in a split-plot design. The irrigation treatments were in the main plot and the foliar application was in the sub-main plot with four replicates, and each replicate contained five plants. Data from all experiments were subjected to analysis of variance using Costat Statistical Software. L.S.D. at 5% was used to compare the means of treatments. According to Snedecor and Cochran (1989).

3. Results and Discussion

3.1. Effect of irrigation intervals and some natural anti-transpiration on vegetative growth of *Viola odorata* L. plants

3.1.1. Vegetative growth parameters

Data of vegetative growth parameters, i.e., fresh weight of leaves/ plant (g), dry weight of leaves / plant(g), fresh weight of flowers/ plant (g) and dry weight of flowers/ plant (g) of whole plant as affected by irrigation intervals and foliar application of anti-transpirants are presented in Table (3 & 4).

Effect of irrigation intervals

Concerning the effect of irrigation intervals on vegetative growth parameters data in Table 3& 4 clearly show that fresh weight of leaves/ plant (g), dry weight of leaves / plant (g), fresh weight of flowers/ plant (g) and dry weight of flowers/ plant (g) as influenced by irrigation intervals. The highest significant values of the studied parameters were recorded when the plants irrigated every 1 day during both seasons. Compared to other irrigation treatments which resulting in significant differences in most cases, however, the highest rate of irrigation treatments (irrigated every 2 days) gave the next higher values of vegetative parameters. Meanwhile, (irrigated every 3 days) produced the lowest growth in the first and second seasons. The highest values of herb fresh weight /plant (202.50 and 205 g), dry weight of herb/plant (46.50 and 48.50 g) and flowers fresh weight /plant (35.50 and 37.50 g) and flowers dry weight /plant (9.50 and 9.75 g) were recorded when plants were irrigated every one day per plant in the first and second seasons, respectively. Also, the differences between the highest irrigation intervals and the lowest one was significant in both seasons. However, the decrease in irrigation intervals reduced soil moisture content and caused quandary of plants to get water requirements and these in turn might reduction in vegetative growth. The previous result is agreed with those obtained by Sorkhi (2020) on *Thymus vulgaris*; Khater, (2010) on *Nicotiana gluca* and Kosterna *et al* (2012) on celeriac. This could be explained by increasing water quantity applied to plant led to moisture availability content in the soil and needed nutrients for growth around the roots, this in turn might the plant metabolism that leads to increase vegetative growth measurements. This result were coincided with those obtained by Gamez, *et al.,* (2015) on quinoa; Moussavi *et al.,* (2011) on Ajowan; Massoud, Hekmat *et al.,* (2010) on marjoram; El-Mahrouk (2000) on *Swiettenia mahogoni* L Jaq; Kandeel and Peter, (2001) on *Rosmarinus officinalis* L. plant; Soha and Khalil, 2015 on *Rosmarinus officinalis*; Barghamadi*,et al.,* (2015) on ajowan (*Carumcopticum*) ;El-Mekawy (2013)on *Niglla sativa*; Hassan Bazaid (2013) on *Rosmarinuso fficinalis*; Rabia*et al.,* (2013) on *Echinacea purpurea* .

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Table 3: Effect of irrigation intervals and some natural anti-transpiration on herb fresh and dry weight/plant (g) of *Viola odorata* (Violet) plant.

Treatments	Herb fresh weight/plant (g)									
	First season					Second season				
	AT 0	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I1	175.00	202.50	175.50	195.50	187.13	179.50	205. 00	178.00	198.50	190.25
I2	160.00	170.00	165.50	175.75	167.81	165.50	175. 00	170.50	178.00	172.25
I3	135.50	145.00	140.00	145.50	141.50	135.50	147.50	142.5	148.00	143.38
Mean	156.83	172.50	160.33	172.25	165.48	160.17	175.83	163.67	174.83	168.63
L.S.D at 0.05 for irrigation			23.06			24.54				
L.S.D at 0.05 anti-transpiration			12.49			12.35				
L.S.D at 0.05 for interaction			15.21			15.43				

Treatments	Herb dry weight/plant (g)									
	First season					Second season				
	AT 0	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I1	35. 50	46.5	37.50	42.50	40.50	38. 50	48.5	39.5	43.5	42.50
I2	32.75	38. 5	36.0	38.0	35.58	33. 5	40. 0	37.0	40.0	38.50
I3	28.50	33.0	31.5	32.0	31.25	29.5	34.15	35.5	36.0	33.79
Mean	32.25	39.33	35.00	37.50	35.78	29.50	41.33	37.33	39.83	36.997
L.S.D at 0.05 for irrigation					13.87			12.80		
L.S.D at 0.05 anti-transpiration					5.33			5.10		
L.S.D at 0.05 for interaction					10.26			11.40		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

Table 4: Effect of irrigation intervals and some natural anti-transpiration on flowers fresh and dry weight/plant (g) of *Viola odorata* (Violet) plant.

Treatments	Flowers fresh weight/plant (g)									
	First season					Second season				
	AT 0	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I1	32.00	35.50	31.50	33.50	33.13	34.50	37. 50	34.00	35.50	35.38
I2	27.00	30.00	26.50	28.75	28.06	28.50	33. 0	29.50	30.00	30.25
I3	21.50	24.00	21.00	21.50	22.00	22.50	25.50	21.50	22.00	22.88
Mean	26.83	29.83	26.33	27.73	27.68	28.50	32.00	28.33	29.17	29.50
L.S.D at 0.05 for Irrigation				3.05				3.54		
L.S.D at 0.05 anti-transpiration				5.49				5.35		
L.S.D at 0.05 for interaction				5.21				5.43		

Treatments	Flowers dry weight/plant (g)									
	First season					Second season				
	AT 0	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I1	8. 75	9.50	8.50	9.75	9.25	8. 75	9.75	8.75	9.25	
I2	6.50	6. 75	6.50	6. 50	6.56	6. 75	7. 50	6.50	6.75	6.88
I3	4.25	5.00	4.50	4.50	4.66	5.25	5.75	5.00	4.75	5.19
Mean	6.5	7.17	6.5	6.83	6.75	6.92	7.67	6.75	6.92	7.07
L.S.D at 0.05 for irrigation					1.87			1.80		
L.S.D at 0.05 anti-transpiration					1.33			1.11		
L.S.D at 0.05 for interaction					1.26			1.42		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

Effect of anti-transpirants:

Regarding the Effect of anti-transpirants on vegetative growth parameters, it is clear from the data present in Table 3 & 4 that, the effect of foliar application treatments of antitranspirants on fresh weight of leaves/ plant (g), dry weight of leaves / plant (g), fresh weight of flowers/ plant (g) and dry weight of flowers/ plant (g) were significantly increased in response to spraying all foliar application as compared to the untreated plants (AT 0) as control. Data from the same Table 3&4 obviously show that the highest significant values of the mentioned parameters were recorded with spraying plants by (AT 1) humic acid 2kg/feddan once, 21 days before cuts followed by spraying (AT 3) spraying with $MgCO_3$ (2%) then spraying with (AT 2) $CaCO_3$ (2%). These increases were true in the two seasons of the experiment. It could be summarized that, foliar application of antitranspirants gained superiority in plant growth characters if compared with (AT 0) control treatments, and antitranspirants application of humic acid gave the topping vigor of plant growth. The use of antitranspirants make a layer on the surface of the leaves which are biodegradable organic film formulated to protect plants from damage caused by immoderate transpiration or water loss through leaves, may help in keeping healthy plant during the growing season. These results could be explained on the ground that the increments happened in vegetative growth on violet plant, i.e. fresh weight of leaves/ plant (g), dry weight of leaves / plant (g), fresh weight of flowers/ plant (g) and dry weight of flowers/ plant (g) treated with antitranspirants such as humic acid comparatively to those of control was possibly due to two aspects. First is the protection of tissues from climatic condition, and second is the increase of water potential at a time when the growth plant was more dependents on water status than on photosynthesis. This positive effect on vegetative growth has reflection on total leaves and flowers and its contents. These results were in harmony with those obtained by Sorkhi, 2020 on Thymus vulgaris; Mohamed and Ghatas (2016) on *Viola odorata* L. plants; Abedini *et al.,* (2015) on Pot marigold; Barghamadi *et al.,* (2015) on ajowan (*Carum copticum*) ;Massoud, Hekmat *et al.,* (2010) on marjoram; Afify *et al.,* (2001) on roselle plant ;Bown (1995) Encyclopedia of Herbs; Eid and Abouleila (2006) on croton (*Codium variegatum*); Gewefiel *et al.,* (2009) on *Nicotiana gluca*; Al-Moftah and Al-Hamaid (2005) on tuberose .

Interaction effect

Data presented in the same tables show that, the parameters of growth plant of violet plants were significantly affected by the interaction between irrigation intervals and foliar application of antitranspirants treatments in the two seasons. However the highest vegetative parameters resulted from irrigation plants every one day interval and sprayed with (AT 1) humic acid, followed by Spraying with (AT 3) $MgCO_3$ (2%) then (AT 2) $CaCO_3$ (2%) which had more vegetative growth measurements. Compared with (AT 0) the untreated plants. Plants irrigation every day interval and sprayed with humic acid recorded the highest values of fresh weight of leaves/ plant (g), dry weight of leaves / plant (g), fresh weight of flowers/ plant (g) and dry weight of flowers/ plant (g) followed by irrigation plants every one day interval and spraying with $MgCO_3$ (2%) then $CaCO_3$ (2%)which had more vegetative growth during both seasons of the experiment. These results may be due to the effect of humic acid which contains many organic compounds, amino acids and nutrients, especially potassium, which plays an important role in many processes within the plant, including regulating the work of stomata, as the accumulation of potassium in the guard cells serves as the driving forces for the process of opening and closing stomata, and this process is related to the level of potassium in the cell and sugars. Also, humic acid increases the permeability of cell membranes and nutrient absorption, which leads to an increase in photosynthesis and the formation of carbohydrates and proteins, which are the basic building blocks of enzymes and chromosomes, and thus reduces acids. Decomposing amino acids, including proline, by reducing stress on the plant, because proline doubles to 12.5 times in plants exposed to stress. Obtained results are in confirmed with those reported by Sorkhi, 2020 on *Thymus vulgaris*; Mijani, *et al.,* (2015) on of hibiscus (*Hibiscus sabdarifa*); Saif EL-Deen and Abd El-Hameed (2010) on globe artichoke ;Nermeen (2011) on *Monster deliciosa* leaves; Song *et al.,* (2011) on *Rosa hybrida* L. and Al-Moftah and Al-Hamaid (2005) on tuberose .

3.2. Effect of irrigation intervals and some natural anti-transpiration on leaves and flowers concrete % of *Viola odorata* Plants

3.2.1. Effect of irrigation intervals

Response of leaves and flowers concrete (%) of violet plant to irrigation intervals during both seasons, data presented in Table 5 indicated that the concrete percentage of leaves and flowers of *Viola odorata* Increased when the plants irrigated every two days that gained the highest percentage of leaves and flowers concrete %. (0.119 and 0.123%/plant) in the 1stand (0.120 and 0.124%/plant) in the 2ndseasons, respectively. This was followed by the second treatment which was irrigated every one day (0.114& 0.118%/plant) in the first and (0.114& 0.120%/plant) in the second seasons, respectively. However, irrigated every three days interval recorded the lowest values of leaves and flowers concrete

% of violet plant during both seasons of the experiment. The results may be attributed to the fact that the violet plant is one of the plants that belong to the temperate regions and the tropical mountains, Marcussen (2006) on *Viola odorata* which give the highest percentage of leaves and flowers concrete % when exposed to a limited shortage of water represented by irrigated every two days intervals. As for irrigation every three days intervals, it negatively affects vegetative growth, as well as leaves and flowers concrete %.These results coincided with those obtained by Gamez, *et al.,* (2015) on quinoa ;Sorkhi, 2020 on *Thymus vulgaris*;Moussavi *et al.,* (2011) on Ajowan; Massoud, Hekmat *et al.,* (2010) on marjoram;Hekmat*et al.,* (2016) on *Rosmarinusofficinalis*;Abd El-Wahab (2002) on Rosemary and Geranium plants; Eid and Abouleila (2006) on*Codium variegatum* ; Mirsa and Strivastava (2000) on Japanese mint; Baeck *et al.,* (2001) on sweet basil and Baher *et al.,* (2002) on *Satuejahortensis*.

Table 5: Effect of irrigation intervals and some natural anti-transpiration on leaves and flowers concrete percentage of *Viola odorata* (Violet*)* plant.

Treatments	Leaves concrete %									
	First season					Second season				
	AT 0	AT 1	AT 2	AT 3	Mean	AT 0	AT 1	AT 2	AT 3	Mean
I1	0.114	0.115	0.111	0.114	0.114	0.114	0.116	0.112	0.115	0.114
I2	0.118	0.121	0.117	0.119	0.119	0.118	0.122	0.120	0.121	0.120
I3	0.110	0.113	0.110	0.112	0.111	0.111	0.115	0,111	0.113	0.112
Mean	0.114	0.116	0.113			0.114	0.117	0.114	0.116	
L.S.D at 0.05 for irrigation				0.005				0.005		
L.S.D at 0.05 anti-transpiration				0.001				0.001		
L.S.D at 0.05 for interaction				0.003				0.003		

Treatments	Flowers concrete %									
	First season					Second season				
	AT 0	AT 1	AT 2	AT 3	Mean	AT 0	AT 1	AT 2	AT 3	Mean
I1	0.117	0.119	0.117	0.119	0.118	0.119	0.122	0.117	0.120	0.120
I2	0.121	0.125	0.122	0.123	0.123	0.122	0.126	0.123	0.124	0.124
I3	0.118	0.122	0.119	0.120	0.120	0.120	0.124	0.120	0.122	0.121
Mean	0.119	0.122	0.119	0.121		0.120	0.124	0.120	0.122	
L.S.D at 0.05 for irrigation					0.004			0.003		
L.S.D at 0.05 anti-transpiration					0.002			0.002		
L.S.D at 0.05 for interaction					0.006			0.007		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

Effect of antitranspirants

The influence of studied antitranspirants treatments on leaves and flowers concrete % of violet plant was illustrated in Table 5 show clearly, that, all antitranspirants treatments caused an increment in leaves and flowers Concrete % compared with (AT 0) Control plants (Spraying with water). Moreover, sprayed with (AT1) Humi acid, gave the highest leaves and flowers Concrete %(0.116and 0.122%/plant) in the 1stand (0.117 and 0.124%/plant) in the 2ndseasons, respectively. It could be concluded that, the anti-transpirants as foliar for Violet plants enhanced the leaves and flowers concrete %. This result, refers to the superiority effect of the antitranspirants which are make a layer on the surface of the leaves to protect plants from damage caused by immoderate transpiration of water loss through different vegetative plant organs, consequently enhancing the vegetative growth. This positive effect on vegetative growth has reflection on leaves and flowers concrete %. In our studies, humic acid as antitranspirants at 2kg/feddan was still the most superior effective in inducing the highest leaves and flowers concrete %. This result was clearly coincided with that obtained by Sorkhi, 2020 on *Thymus vulgaris*; Mohamed and Ghatas.,2016 on *Viola odorata* L. plants; Abedini *et al.,* (2015) on Pot marigold; Barghamadi*, et al.,* (2015) on Ajowan; Massoud, Hekmat *et al.,* (2010) on marjoram and Al-Moftah and Al-Hamaid (2005) on tuberose.

Effect of interaction

Table 5 indicates that, the interaction between irrigation intervals and foliar antitranspirants had significant effect on leaves and flowers concrete % of violet plants in both seasons. As it has been

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mentioned, under Irrigated every 2-days interval applied to plants beside spraying with sprayed with (AT 1) humic acid, gave the highest value of leaves and flowers concrete % of violet plant which scored 0.121 and 0.125%/plant) in the 1st and (0.122 and 0.126%/plant) in the 2nd seasons, respectively. These may be due to the secondary structures in plants that can develop by stress exposed to a limited shortage of water represented by irrigated every two days intervals because the plant tends to build these secondary structures of the oil slowly by slowing the growth of plants as a result of stress at the expense of vegetative growth, which needs more water to accelerate growth that reflected a significant increase on leaves and flowers concrete %. While irrigation every three days intervals led to a decrease in the yield and then a decrease in the leaves and flowers concrete %. These results coincided with those obtained by El-Mekawy (2012): on *Niglla sativa* L. plant reported that, growth and essential oil production are influenced by various environmental factors, such as water stress represented by the spacing of irrigation intervals Rabia *et al.,* (2013): Response of *Echinacea purpurea* L, reported that secondary products of plants can be altered by water stress which is a major factor affecting the synthesis of natural products. These results coincided with those obtained by Sorkhi, 2020 on *Thymus vulgaris*; Mijani, *et al*., (2015) on of hibiscus (*Hibiscus sabdarifa*); Massoud, Hekmat *et al.,* (2010) on marjoram; Abd El-Wahab (2002) on Rosemary and Geranium plants; Eid and Abouleila (2006) *Codium variegatum*; Al-Moftah and Al-Hamaid (2005) on tuberose; Mirsa A. and Strivastava (2000) on Japanese mint; Baeck *et al.,* 2001 on sweet basil and Baher *et al.,* (2002).on *Satueja hortensis* L .

3.3. Chemical composition

3.3.1. Effect of irrigation intervals

Concerning to the effect of the irrigation intervals, obtained results in Tables 6 & 7 which pointing to the effect of irrigation intervals on nitrogen % and phosphors percentage of (*Viola odorata*) Violet plant show that, application of irrigation intervals in both seasons of the experiment significantly increased the average values of N, P, K concentration of in the tissues of violet plant. Whereas, irrigated every 1 day gave the highest values of N, P, K concentration.

Table 6: Effect of irrigation intervals and some natural anti-transpiration on nitrogen % and phosphors percentage of *Viola odorata* (Violet*)* plant**.**

	Nitrogen %									
	First season					Second season				
Treatments	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I_1	3.21	3.48	3.32	3.38	3.35	3.24	3.51	3.31	3.36	3.36
I_2	2.84	3.19	2.94	3.15	3.03	2.82	3.22	2.91	3.17	3.03
I_3	2.33	2.82	2.36	2.71	2.56	2.35	2.86	2.35	2.73	2.58
Mean	2.79	3.16	2.87	3.08	2.98	2.80	3.20	2.86	3.10	2.99
L.S.D at 0.05 for Irrigation				0.51				0.52		
L.S.D at 0.05 anti-transpiration				0.37				0.36		
L.S.D at 0.05 for interaction				0.31				0.30		
	Phosphors %									
	First season					**Second season**				
Treatments	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**	**AT 0**	**AT 1**	**AT 2**	**AT 3**	**Mean**
I_1	0.35	0.37	0.36	0.36	0.36	0.36	0.39	0.35	0.36	0.37
I_2	0.32	0.33	0.32	0.32	0.32	0.31	0.34	0.31	0.33	0.32
I_3	0.22	0.25	0.23	0.23	0.23	0.23	0.24	0.23	0.24	0.24
Mean	0.30	0.32	0.30	0.30	0.31	0.30	0.32	0.30	0.31	0.31
L.S.D at 0.05 for irrigation				0.05				0.05		
L.S.D at 0.05 anti-transpiration				0.10				0.10		
L.S.D at 0.05 for interaction				0.02				0.02		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

Table 7: Effect of irrigation intervals and some natural anti-transpiration on potassium percentage of *Viola odorata* (Violet) plant.

Treatments	Potassium %									
	First season					Second season				
	AT_0	AT_1	AT_2	AT_3	Mean	AT_0	AT_1	AT_2	AT_3	Mean
I_1	2.55	2.88	2.58	2.62	2.67	2.51	2.91	2.55	2.64	2.65
I_2	2.34	2.55	2.41	2.48	2.45	2.31	2.51	2.42	2.45	2.42
I_3	2.11	2.35	2.14	2.12	2.18	2.13	2.33	2.19	2.14	2.20
Mean	2.33	2.59	2.38	2.41	2.43	2.32	2.58	2.39	2.41	2.42
L.S.D at 0.05 for irrigation				0.23				0.22		
L.S.Dat 0.05 anti-transpiration				0.25				0.24		
L.S.D at 0.05 for interaction				0.32				0.31		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

These results may be attributed to the roles of humidity in soil properties which improved the physical and chemical soil properties, this finding could be attributing to the fact that when soil moisture decreased, nutrient movement in the soil also decreases and the flow of nutrients around the root area is reduced. So, when the plant gets enough of the irrigation water. This is reflected on increasing nutrients release availability, i.e. N, P and K uptake. These finding are in agreement with those of Sorkhi, 2020 on *Thymus vulgaris*; Soltan and Mansourifar. 2017 on *Nigella sativa*; Moussavi *et al.,* (2011) on Ajowan; Abedini *et al.,* (2015) on Pot marigold; Massoud, Hekmat *et al.,* (2010) on marjoram; Hekmat *et al.,* (2016) on *Rosmarinusofficinalis*;Kosternae*t al.,* (2012); Kosterna *et al.,* (2012) on celeriac.

3.2. Effect of antitranspirants

Regarding to the effect of spraying Violet plant with (AT 1) humic acid at 2kg/feddan, (AT 2) $CaCO_3$ (2%) and (AT 3) $MgCO_3$ (2%) data in Table 5 indicate a significantly effect on N, P, K percentage in the tissues of violet plant compared with the untreated plants (AT0) Control plants (Spraying with water once, 21 days before cuts during both seasons of 2018/ 2019 and 2019/ 2020. Data clearly show that, the highest significant values of N, P, K percentage were recorded with spraying humic acid at 2kg/feddan followed by (AT 3) $MgCO_3$ (2%)and finally (AT 2) $CaCO_3$ treatment While the untreated plants (AT 0) Control recorded the lowest values of the mentioned parameters in both seasons. The obtained results are in accordance with the previous investigation which indicate to the same direct correlation between antitranspirants materials and N, P, K percentage in tissues of plant. These result are in harmony with those obtained bySorkhi, 2020 on *Thymus vulgaris*; Mohamed and Ghatas,2016 on *Viola odorata*L. Plants; Abedini *et al.,* (2015) on Pot marigold; Barghamadi *et al.,* (2015) on ajowan and Al-Moftah and Al-Hamaid (2005) on tuberose.

3.3. Effect of interaction

The effect of interaction between irrigation intervals and antitranspirants on chemical contents of violet plant, i.e; N, P, K percentage are presented in Tables 6 &7, in the present investigation, application of irrigation intervals had a significant effect on N, P percentage in violet plant (Anwar, 2005 and Saif El-Deen and Abd El-Hameed, 2010). Data present in Table 5 showed that the parameters of N, P, K percentage in violet plant were significantly affected by the interaction between irrigation intervals and foliar application of antitranspirants treatments during both seasons. Data illustrate in Table 5, show that there was a significant increase in N, P percentage of violet plant in both seasons as affected by foliar with different antitranspirants under shorted irrigation intervals during both seasons. These results may be attributed to the fact that convergence of irrigation periods and spraying with anti-transpiration improves the water condition and reduces water stress in the plants cells which provides favorable conditions for the movement and transitional of elements nutrient produced, this relationship eventually leads to improving plant growth by continuous acting carbonate plants and its reflection in Concentration of N, P, K percentage in plant tissue. This observation agrees with the report by Mijani, *et al.,* (2015) on of hibiscus (*Hibiscus sabdarifa*) and Al-Moftah and Al-Hamaid (2005) on tuberose. With respect to the effect of interaction among irrigation intervals and foliar application of different antitranspirants on chemical composition of violet plant, it is evident from such data present in Table 5 that the mean values

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of N, P, K percentage in violet plant were significantly affected and the best records of previous characters were obtained by plants Irrigated every 1 day interval applied to plants beside spraying with sprayed with(AT 1) humic acid compared with the other treatments during both seasons of the experience.

3.4. Total carbohydrate content and total chlorophylls in leaves of *Viola odorata* L.

3.4.1. Effect of irrigation intervals

Data in (Table 8) show that increasing the irrigation water intervals resulted in gradually increasing in total carbohydrates percentage / plant and total chlorophylls in leaves of *Viola odorata* L. These increase were significant in most cases during both seasons. The maximum mean values were obtained as a result of irrigation intervals every 1day, which were registered (18.11 and 17.62%) and (226,18 and 229,15 %) of total carbohydrates and total chlorophylls in leaves of *Viola odorata* L*,* in the first and second seasons respectively. These results are in conformity with those obtained by Alireza *et al.,* 2011 on *matricaria chamomilla* L; Abd El- Wahab *et al.,* (2015) on *Rosmarinus Officianalis* L. plant; Ekren, *et al.,* 2012 on (*Ocimum basilicum* L.); Rabia *et al.,* 2013 on *Echinacea purpurea* L; El-Mekawy., 2013 on *Niglla sativa* L; Hassan *et al.,* 2013 on *Rosmarinus officinalis* L.; Khattab *et al.,* 2002 on *Salvia splendens*. They found that total carbohydrates content and total chlorophylls (%) decreased as irrigation intervals increased during both seasons.

Table 8: Effect of irrigation intervals and some natural anti-transpiration on total carbohydrates percentage and total chlorophylls (mg/100g FW) percentage of *Viola odorata* (Violet*)* plant.

Treatments	Total Carbohydrates %									
	First season					Second season				
	AT_0	**AT_1**	**AT_2**	**AT_3**	**Mean**	**AT_0**	**AT_1**	**AT_2**	**AT_3**	**Mean**
I_1	15.11	18,11	15.15	16.85	16.31	15.77	17,62	15.23	16.75	16.34
I_2	11.32	14,77	14.12	14.25	13.62	11.23	14,75	13.93	14.15	13.52
I_3	10.34	12.86	12.10	12.31	11.90	10.55	12.64	12.15	12.22	11.89
Mean	12.26	15.25	13.79	14.47	13.94	12.52	15.00	13.77	14.37	13.92
L.S.D at 0.05 for irrigation				1.13				1.15		
L.S.D at 0.05 anti-transpiration				0.34				0.31		
L.S.D at 0.05 for interaction				1.13				1.41		
	Total chlorophylls (mg/100g FW)									
	First season					Second season				
Treatments	**AT_0**	**AT_1**	**AT_2**	**AT_3**	**Mean**	**AT_0**	**AT_1**	**AT_2**	**AT_3**	**Mean**
I_1	213.11	226,18	216.15	238.15	223.40	218.11	229.15	212.15	231.45	222.72
I_2	188.52	204.54	198.33	215.66	201.76	189.58	209.14	200.10	211.44	202.57
I_3	162.34	182.71	168.17	190.14	175.84	170.44	177.66	165.87	188.96	175.73
Mean	187.99	204.48	194.22	214.65	200.33	192.71	205.32	192.71	210.62	200.34
L.S.D at 0.05 for irrigation				16.33				17.41		
L.S.D at 0.05 anti-transpiration				5.34				5.37		
L.S.D at 0.05 for interaction				31.45				30.14		

AT 0= spraying with water, AT 1= spraying with humic acid, AT 2 spraying with $CaCO_3$ and AT 3= spraying with $MgCO_3$ I1= every 1 day, I2= every 2 days and I3 = every 3 days irrigation intervals

Effect of antitranspirants

Concerning the total carbohydrate percentage and total chlorophylls (%) per plant in leaves, the data in Table (8) show that all antitranspirant treatments exhibited stimulatory effect on carbohydrates accumulation in leaves compared with (AT0) control treatment. The differences between the treatments and control were significant during both seasons. The highest values were resulted from plants sprayed with (AT1) humic acid at 2kg/feddan, then (AT 3) $MgCO_3$ (2%), However, the lowest average of total carbohydrates percentage recorded by spraying Violet plant with $CaCO_3$ at 2% during both seasons. These results are in agreement with those obtained by Mohamed and Ghatas.,2016 on *Viola odorata* L. plants and Mahfouz (1997) on roselle.

Effect of interaction

It is clear from data in Table (8) that, the combination treatments between irrigation intervals and antitranspirant materials had major effect on carbohydrate percentage and total chlorophylls. The content (%) reached to its extreme mean values as a result of irrigation intervals every 1 day and sprayed with (AT 1)humic acid at 2kg/feddan, then (AT 3) $MgCO_3$ (2%) showed significant increase in total carbohydrate content (%)and total chlorophylls in leaves of violet plants compared with control treatment(AT 0). On the other hand, the minimum value of Total carbohydrates content (%) and total chlorophylls were obtained as a result of (AT 0) control and sprayed with $Coco_2$ 2%. These results hold true during both seasons, and agree with those of Sorkhi (2020) on *Thymus vulgaris*; Mijani, *et al*., (2015) on of hibiscus (*Hibiscus sabdarifa*)'; Copetta, *et al.,* (2011); El Mekawy (2012) and Hassan *et al.,* (2013); Pirzad, *et al.,* (2011) on *Matricaria chamomilla* L. The increase in total carbohydrates% and total chlorophylls as a result of increasing irrigation water intervals and antitranspirant especially humic acid may be due to keeping the soil moisture content and closing the stomata as a result of spraying with humic acid which reduced the negative effects of drought stress on the plant which due to increase in chlorophyll content in plants and these reflect on improved carbohydrate content.

3.5. Essential oil constituents (%)

The volatile oil constituents of violet leaves effected of irrigation intervals (Irrigated every 1 day, every 2 days and every 3 days) are summarized in Tables 9 & 10. The GC-MS analysis revealed the presence of 25 identified compounds, representing 88.67,89.18 and85.87 % of theoil leaves, respectively.

Table 9: Effect of irrigation intervals on essential oil constituents (%) of *Viola odorata* (Violet) plant

No.	Component name	Irrigation intervals		
		Every 1 day	**Every 2 days**	**Every 3 days**
		Component Value (%)		
1	**butyl-2-ethylhexylphthalate**	16. 72	17.03	16.65
2	**Ethyl benzene**	6.56	7.18	6.35
3	**5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy)butan-2-ol**	10.32	10.34	10.23
4	**β-Citronellol**	2.88	2.90	2.86
5	**Linalyl acetate**	2.80	2.81	2.75
6	**epi-α-cadinol**	3.81	3.83	3.76
7	**benzyl benzoate**	2.71	2.73	2.65
8	**n-hexanol**	1.56	1.61	1.46
9	**trans-2-hexen-1-ol**	1.40	1.42	1.53
10	**3-Hexenyl Acetate**	8.02	8.06	7.92
11	**Benzyl alcohol**	0.89	0.92	0.88
12	**Pentane**	1.32	1.35	1.14
13	**2-Propionic acid, trimethylsilyl ester**	1.61	1.63	1.53
14	**n-heptenol**	1.52	1.57	1.51
15	**trimethylcyclohex-2-enone**	1.60	1.62	1.61
16	**(E,E)-hepta-2,4-dienal**	1.31	1.32	1.11
17	**hexanoic acid**	3.22	3.26	3.11
18	**limonene c acid**	3.11	3.13	3.08
19	**Nonacosane**	2.14	2.17	2.12
20	**Tetracosane**	1.36	1.38	1.05
21	**tridecane**	1.02	1.02	1.00
22	**Urs-12-ene**	4.05	4.10	4.02
23	**4-epi Friedelin**	3.73	3.75	3.65
24	**9,12,15-octadecatrienoic acid**	2.56	2.58	2.44
25	**eugenol**	1.45	1,47	1.46
*	**Unidentified**	11.33	10.82	14.13
	Total	100	100	100

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Table 10: Effect of spraying with humic acid (natural anti-transpiration) on essential oil constituents (%) of *Viola odorata* (Violet*)* plant

	Irrigated every 2 days intervals and spraying with humic acid(natural anti-transpiration)	
No.	**Component name**	**Value (%)**
1	**butyl-2-ethylhexylphthalate**	17.07
2	**Ethyl benzene**	7.24
3	**5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy)butan-2-ol**	10.45
4	**β-Citronellol**	2.95
5	**Linalyl acetate**	2.83
6	**epi-α-cadinol**	3.87
7	**benzyl benzoate**	2.78
8	**n-hexanol**	1.60
9	**trans-2-hexen-1-ol**	1.43
10	**3-Hexenyl Acetate**	8.08
11	**Benzyl alcohol**	0.95
12	**Pentane**	1.52
13	**2-Propionic acid, trimethylsilyl ester**	1.65
14	**n-heptenol**	1.62
15	**trimethylcyclohex-2-enone**	1.65
16	**(E,E)-hepta-2,4-dienal**	1.36
17	**hexanoic acid**	3.32
18	**limonene c acid**	3.23
19	**Nonacosane**	2.22
20	**Tetracosane**	1.05
19	**tridecane**	0.89
20	**Urs-12-ene**	4.34
21	**- 4- epi Friedelin**	3.83
22	**9,12,15-octadecatrienoic acid**	2.55
23	**eugenol**	1.56
*	**Unidentified**	9.96

The main constituents of the volatile oil leaves was Butyl-2 ethylhexylphthalate (16.72, 17.03 &16.56%) followed by5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy) butan-2-ol (10.32, 10.34&10.23%), 3-Hexenyl Acetate (8.02, 8.0 6&7.92%), Ethyl benzene (6.56, 7.18&6.35%), Urs-12-ene (4.05, 4.10&4.02%), epi-α-cadinol (3.81, 3.83&3.76 %), 4-epi-Friedelin (3.73, 3.75&3.65%), for irrigated every 1 day, Irrigated every 2 days and irrigated every 3 days, respectively. Were also found some components that it is distinguished by the Egyptian *violetodorata* L. leaves oil which were hexanoic acid, limonene c acid, dodecan-1-ol,2,6-nonalnadi, E, E)-hepta-2,4-dienaleugenol, and tridecane were also found to be minor components of the *V. odorata* L. leaves oil which were. β-Citronellol, benzyl benzoate, Benzyl alcohol,9,12,15-octadecatrienoic acid, eugenol, Pentane, 2-Propionic acid, trimethylsilyl ester, trimethylcyclohex-2-enone, Nonacosane, Tetracosane and tridecane. Among the results obtained in this analysis is that the highest percentage of the mean compounds were obtained from irrigation every two days. While, the volatile oil constituents of violet leaves effected of irrigated every 2 days and spraying with humic acid included 25compounds were identified, representing 90.04%of the oil and the most important of them (Butyl-2 ethylhexyl phthalate) (17.07%). Followed by5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy) butan-2-ol (10.45%), 3-Hexenyl Acetate (8.08%), Urs-12-ene (4.34%), epi-α-cadinol(3.87%) hexanoic acid (3.32%), limonene c acid (3.23%), β-Citronellol (2.95%), and Linalyl acetate (2.83%), benzyl benzoate(2.78%) and other compounds already mentioned, respectively. In this analysis, it was observed that the percentage of chemical components increased by irrigated every 2 days and spraying with humic acid. These is confirmed by Mohamed and Ghatas.,2016;Karioti , *et al.,* 2011; Saint-Lary *et al.,* 2014, Mittal *et al.,* 2015and Akhbari *et al.,* 2012 on *Viola odorata* who declared that, the analysis of essential oil composition of the leaves of *Viola odorata* L. revealed the presence of the aforementioned mean compounds, which presence of 25 identified compounds, and the mean component were butyl-2-ethylhexylphthalate and and 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone being the two main components of*Viola odorata* oil.

Conclusion

Many studies have indicated that water stress leads to great damage to the plant and a decrease in the yield, leaves and flowers concrete percentage and the active ingredients, and that spraying some organic and chemical compounds such as humic acid as anti-transpiration on the plant would increase the plant's tolerance to stress for drought. These all finding emphasize the importance of determining the interactive effects between irrigation intervals and antitranspirants to find out the optimum combinations for maximum leaves and flowers yield, the treatment of 1-day irrigation interval with 2 kg/fed of humic acid sprayed as antitranspirants application was the best combination of vegetative parameters. However, the higher % of concrete Leaves and flowers obtained from treated the plants with the treatment of 2 days irrigation interval with 2 kg/fed of humic acid and it is recommended for violet plant grown under sandy soil conditions in order to get higher economical yield. The highest value of main constituents of the volatile oil leaves obtained under irrigated every 2-day interval and sprayed with (AT1) Humic acid gave the highest value of main constituents which were Butyl-2 ethylhexyl phthalate followed by 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4H)-benzofuranone-2-yloxy) butan-2-ol, 3-Hexenyl Acetate.

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