Evaluating the Effect of Nutrition on the Growth and Flowering of Saintpaulia Ionantha Wendl

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Abstract - Saintpaulia, commonly known as African violet, is one of the most popular flowering houseplants, which needs a proper cultivation to improve vegetative and reproductive growth. It has been proved that the application of complete fertilizer, a proper beddingand the use of proper nutrition has resulted in better growth and better flowering for most plants.In order to grow better, a separate experiment was conducted to investigate factors affecting the growth and flowering of this plant. In this experiment, three levels of nutrition were tested (solid fertilizer (NPK) 20:20:20, solid phosphorous fertilizer 13:40:13 and liquid fertilizer (NPK) with the ration of 20.6:7.7:7.7). The whole experiments were carried out as a factorial experiment in a completely randomized factorial design with 5 replications. Most ofthe measured traits were significantly affected by the treatments of these three experiments.

Keywords: Nutrition, Fertilizer, Light, Climatic Conditions

Resource Review

General Principle about Saintpaulia

Saintpaulia is a modern ornamental plantand is economically important. This plant has a rosette growth habit and hairy and ovate leaves. The flowers in this plant are composed of five round petals on a short stem. The petals are without fuzz on the surface and at the back and on the edges are fuzzy.The color of flowers is usually blue, pink, purple, blue-purple, colorless or almost white with inflorescence. The flowers have two stamens with large kidney-shaped anthers which are yellow. The ovary is short and conical and the style (gynobasic) is long and has an ovate fruit. It is a day-neutral plant and flowering is controlled by temperature and light intensity (Dahl, 1999).

Family and Classification of Saintpaulia

This plant belongs to Gensneriaceae family. There are approximately 125 types and more than 2000 species in this family (Larson, 1992). This family includes many popular houseplants. Other plants of this family that are commercially grown include: Sinningia, Achimenes, Streptocarpus (Dahl and Wilkinz, 2006).

Nutrition of Plants in Soilless Culture

The oldest method for a soilless culture system is the reservoir that solves inorganic chemicals and meets the plant's need. For many years, the system has been used around the world as a commercial tool. In hydroponic culture, water and plant minerals are already completely controlled and, in fact, we choose the formulation of the nutrient solution (Roustaei, 2002).

One of the important nutritional elements that should be used in dietary formulations is the highly used phosphorous element.

Phosphorus

After nitrogen, phosphorus is the most important nutrient element for the plant, and is found in two forms of organic (nucleic acids, phospholipids, phosphoproteins, inositol phosphates and phosphorus sugars) and mineral (mainly calcium, magnesium, iron and aluminum phosphates) in soils (Subaro, 1988).

The Role of Phosphorus

Phosphorus acts as a structural element in the production of nucleic acids,and these acids carry the genetic information in the plant, and phosphorus is the main material that causes the acidic nature of the nucleic acid. Phosphorus plays a role in the process of production and transfer of energy, thus contributing to the metabolic activity of the plant, and indirectly affects the performance of the products. Phosphorous is stored as an organic phytate mixture in the plant and with other elements participates in the structure of pollen grains and is the most

important ingredient in the production of the crop. It is important in the formation of flower and gradation, and also has an increasing effect on the production of reproductive organs (Hasanzadeh et al., 2007).

Use of Phosphorus on the Plant Growthand Development in a Number of Different Experiments

Ghamari et al. (1394) conducted an experiment in order to investigate the effect of different amounts and sources of phosphorous fertilizers on qualitative and qualitative characteristics of two cultivars of stocks. In this research, treatments included triple super phosphate fertilizer in granular and liquid forms in three levels of 50, 100 and 200 mg P/kg of phosphate fertilizer in liquid, granular and organic fertilizer with control (without the application of fertilizer).The results of this experiment showed that using 200 mg P/kg of soil from phosphate fertilizer significantly increased the measured traits (morphological and physiological traits) compared to the control.

The highest amount of chlorophyll was observed in both cultivars of stocks in third level treatments of liquid fertilizer and the third level of granular fertilizer. The highest percentage of phosphorus in the plant was observed in the third level treatments of liquid, granular and organic fertilizers. In both cultivars, the highest amount of fresh and dry weight of shoot, stem height of the flower, inflorescence length and number of florets in florescence were obtained at third level of liquid and granular fertilizers, and then organic fertilizer. Regarding fresh and dry weight of root, the highest amount was obtained in organic fertilizer treatment and then in the third level treatment of fertilizer. In this research, the highest amount of measured traits was observed in liquid fertilizer, which showed a significant difference with other treatments. High phosphorous fertilizer treatments, especially in liquid form than the granular form were obtained. However, due to the fact that biological phosphate treatment resulted in the improvement of growth and the highest root fresh and dry weight, it is recommended to be used as a suitable treatment for the cultivation of stocks.

Abedini et al. (2015), in an experiment, investigate the effect of organic sources and organic (biologic) fertilizeron some of the pelargonium peltatum plant. Phosphate fertilizer was applied in two levels (application and non-application) and different beds of cultivation including eight beds containing garden soil, sand and various organic compounds (volume/volume). In this research, the length of the main stem, number of lateral stems, root length, number of florets in inflorescence, fresh weight of the aerial organs, underground and petals in the plant, petal protein, leaf chlorophyll content, leaf phosphorous, and absorbable phosphorous of the bed were evaluated. The results showed that the main and mutual effects of the two factors on all measured traits were significant. The application of phosphate fertilizer with suitable bedding can be a good supplement to the cultivation bed in order to grow the pelargonium peltatum better.

Tabatabaei et al. (2015) in an experiment investigated the effect of phosphorous and plant density on the amount of flower production and other characteristics of the medicinal plant of Echium. This experiment consisted of four levels of 0, 50, 100 and 150 kg phosphorous fertilizer per hectare as the main factor and three row spacing of 20, 40 and 60 cm as a sub factor. Each experimental unit included 6 planting lines with length of 8 meters. In this experiment, traits such as number of fays to flowering, plant height, average number of flowers per plant, flower yield per unit area and the total biomass were studied. The results showed that the effect of phosphorous fertilizer on the number of flowers per plant and dry flower performance was very significant.

The effect of phosphorous and vermicompost and natural zeolite culture on growth characteristics and zinnia elegance performance in a greenhouse was investigated by Amjazi and Hamidpour (2013). Treatments included phosphorous in three levels (0, 75 and 150 mg/kg soli) and zeolite and vermicompost in three levels (0, 5 and 10% w).The measured traits included leaf area, chlorophyll degree, fresh and dry weight of the plan, leaf dry weight, root dry weight, and concentration of P, Zn and Fe in the aerial organs. Based on this study, mixed zeolite and phosphorous treatments in comparison to the zeolite treatments, had a positive effect on vegetative traits such as total fresh weight of the plant, dry weight of flower, leaf dry weight and root dry weight, which is due to the absorption of dissolved calcium in soil on exchangeable areas of zeolite and as a result of instability of phosphorous as low soluble calcium phosphates and its outcome is an increase in the phosphorous availability of soil soluble.

Baharvandi et al. (2015) conducted a study to investigate the effect of different levels of phosphorous and mycorrhiza on the growth and flowering of polianthes tuberose. Phosphorous was fed from super triple phosphate fertilizer (0, 150 and 250 kg/h) and mycorrhiza was taken at two levels. In this experiment, plant height, virgo height, floret diameter, number of florets, and dry weight of inflorescence were measured. The results of variance analysis showed that application of phosphorous fertilizer significantly increased all the measured traits. In addition, mycorrhiza was meaningful on all traits except the floret diameter. According to the results of this study, treatment of 150 kg/ha mycorrhiza phosphorous has the highest effect on increasing the performance and quantitative traits of polianthes tuberose.

Shafie et al. (2014), in order to investigate the effect of vermicompost fertilizer and phosphorous fertilizer on quantitative and qualitative characteristics of hypericum perforatum, conducted an experiment in form of factorial including three levels of vermicompost (0, 5 and 10 t/ha) and phosphorous fertilizer at three levels

(0,100 and 200 kg/ha) and triple superphosphate fertilizer. The studied traits included: plant height, flowering branches yield, hypericin yield, biological yield and harvest index of flowering branches. The results showed that the phosphorous fertilizer and vermicompost fertilizer separately and the interaction of these two factors were significant in most of the measured traits at 1% level. Comparison of the average of two years showed that the highest flowering branches yield and hypericin yield in treatments of 200 kg of phosphorous fertilizer with 10 ton/ha of vermicompost were 2058 kg and 341.46 g/ha and treatment of 200 kg phosphorous fertilizer with 5 ton/ha of vermicompost was 2139.83 kg and 294.74 g/ha, respectively. The lowest level was related to the control. It seems that the combined use of phosphorous and vermicompost fertilizer can lead to a significant increase in qualitative and quantitative yield of medicinal plant of Hypericum perforatum in comparison with the control.

Nickmehr et al. (2016) evaluated the effect of phosphate solubilizing bacteria and phosphorus fertilizer on yield and yield components of Sesamum indicum oil.The results showed that applying phosphate soil increased seed oil, aerial organs, and stemheight and seed phosphorous concentration significantly compared to the control. Applying phosphorous fertilizer also increased the absorption of phosphorous and zinc in the aerial organ and the concentration of phosphorous and zinc of the seeds. Simultaneous applying of phosphate soil and phosphate solubilizing bacteria increased the measured parameters similarly to the application of high levels of triple superphosphate.

Materials and Methods

Test Duration

This experiment began in a 21-month period from October 2016 and was completed in June 2018.

Place of Testing

This project was carried out in Nowshahr, Mazandaran province, with latitude of 35 degrees and 37 minutes north and a longitude of 50 degrees and 42 minutes east and height of 2.9 meters above sea level.

Test Design

In order to investigate the effect of bedding type, nutrition, optical variables and hormonal treatment of gibberellic acid salicylic acid , this study was carried out in the form of 5 tests as follows;

Investigating the Effect of Nutrition on Growth and Flowering of Saintpaulia Seedlings

Peat moss bedding: perlite (with the same ratio) was used with the best performance among other culture media in first experiment to investigate the effect of nutrition. Fertilizer treatments include: 1. Solid fertilizer with a ration of 20:20:20 with micro elements 2. High phosphorous solid fertilizer with a ratio of 13:40:13 with micro elements 3. Liquid fertilizer with a ratio of 6.20:7.7:7.7 with micro elements.

Herbal Material

Seedlings resulted from tissue cultureincluding three cultivars of Optimara, Rapsody and Tong wensis were used in the 6 to 7-leaf stage with 0.7 cm diameter, which were produced in the tissue culture laboratory of Nowshahr.

Controlling Environmental Factors

Due to the recording of the laboratory temperature, the maximum temperature was set to 25 ° C during the day and 18 ° C at night. Relative humidity of the environment was adjusted to 45-55%.

Measuring Morphological Traits

The number of leaves of each treatment after the completion of each test period was counted. The total number of the appeared flowers on the plant was observed by repeated observations during the plant growth and was continued to the end of experiment. The total number of buds appearing on the plant was counted during the experiment. The number of flowering branches of each treatment was counted after each test period. The number of days to flowering per plant was carried out with repeated notes during the plant growth and until the experiment period. The durability of flowers per plant was repeatedly recorded during the flowering period of the plant from the time when the flower was completely opened until the time when the beauty of flower was maintained completely. The diameter of flowers was measured by Calipers and the mean of diameters was used in statistical analysis. The leaf area was measured using the Digimizer software. The root of plants was kept in oven at 70 ° C for 48 hours and their dry weight was measured. The number of flowers per inflorescence per plantwas counted separately. The emergence of the first bud until the emergence of the last flower on the plant was measured. The distance between flowering periods from the end of each flowering period to the beginning of the next period was measured. The height of each plant was measured with a ruler from the surface of the potting soil. The length of each inflorescence was measured using a ruler per plant.

Statistical Analysis

Statistical analysis was performed with Minitab 16 software and the comparison of averages was performed based on Tukey's test at 5% probability level. Drawing diagrams was performed with Excel software.

Results and Discussion

Studying the Effect of Nutrition and Cultivar on Growth and Flowering of Saintpaulia Seedlings

The results of variance analysis and comparison of data averages showed that nutritional treatments were significant at level 1% in all of the measured traits of Saintpaulia. In addition, the effect of cultivar on all traits except the number of days to flowering and number of flowers in inflorescence was significant (Table 1).

The results of variance analysis and comparison of data averages showed that the interaction effects between nutritional treatments and cultivar had a significant effect on most traits, but it did not have any effect on root dry weight, longevity of the flower, flower diameter, and number of flowering branches (Table 1).

Table 1. Results of Variance Analysis (Mean Square) of the Effect of Nutrition and Cultivar on Morphological Traits of Saintpaulia

Mean Squares														
Sources of changes	**Degrees of freedom**	**Number of leaves**	**Number of flowers**	**Number of buds**	**Number of flowering branches**	**Number of days to flowering**	**Flower longevity**	**Flower diameter**	**Leaf area**	**Root dry weight**	**Number of plants in inflorescence**	**Flowering period**	**Distance between flowering periods**	**Plant height**	**Inflorescence length**
Nutrition	2	23.7**	308.4**	280.9**	9.7**	577.2**	10.1**	1.2**	8.2**	2.4**	5.4**	661.7**	288.1**	7.1**	4.3**
cultivar	1	56.0**	149.6**	128.1**	13.3**	17.6ns	3.4*	1.8**	71.1**	1.7**	0.1ns	128.1**	235.2**	9.4**	46.6**
The interaction of nutrition and cultivar	2	21.4**	6.4*	6.9*	0.5ns	29.7*	1.7ns	0.0ns	10.1**	0.08ns	1.6**	163.7**	46.3**	2.0**	0.7**
Error	20	0.7	1.4	1.4	0.3	7.2	0.6	0.06	0.09	0.02	0.1	1.4	1.6	0.05	0.07

ns, * and -** respectively were insignificant, significant at the probability level of %5 and 1% based on Tukey test.

Table 2. The Results of Comparing the Effect of Nutrition on Morphological Traits of Saintpaulia

	Traits												
Nutrition	**Leaf number**	**Number of flowers**	**Number of buds**	**Number of flowering branches**	**Number of days to flowering**	**Flower longevity (day)**	**Flower diameter (cm)**	**Leaf area (cm^2)**	**Root dry weight (g)**	**Number of flowers in inflorescence**	**Flowering period (day)**	**Distance between flowering periods (day)**	**Plant height (cm)**	**Inflorescence length (cm)**
Complete solid fertilizer	14.8 a	14.3 c	16.8 c	4.4 b	56.7 a	4.9 b	1.7 b	6.6 a	2.7 c	2.9 b	15.0 c	19.9 b	8.2 a	7.4 a
High phosphorous fertilizer	11.8 b	25.4 a	27.4 a	6.2 a	41.7 c	4.2 b	2.4 a	5.4 b	3.7 a	4.3 a	18.8 b	15.3 c	6.6 c	6.1 c
Complete liquid fertilizer	12.7 b	20.2 b	22.2 b	4.6 b	47.4 b	6.2 a	1.9 b	4.9 c	2.7 b	4.0 a	30.6 a	26.0 a	6.9 b	6.7 b

The averages that have at least one common alphabet in each column according to the Tukey test at 1% probability level do not have a significant difference.

Table 3. Results of Comparing the Effect of Cultivar on Morphological Traits of Saintpaulia under Nutrition Treatments

	Traits											
Cultivar	**Number of leaf**	**Number of flower**	**Number of buds**	**Number of flowering branches**	**Number of days to flowering**	**Flower longevity (day)**	**Flower diameter (cm)**	**Leaf area (cm^2)**	**Flowering period (day)**	**Distance between flowering periods (day)**	**Plant height (cm)**	**Inflorescence length (cm)**
Rhapsody	11.7 b	22.2 a	24.2 a	5.7 a	5.4 a	2.3 a	7.2 a	3.0 b	19.4 b	17.6 b	6.7 b	5.5 b
Optimara	14.4 a	17.7 b	20.0 b	4.4 b	4.7 b	1.8 b	4.1 b	3.4 a	23.5 a	23.2 a	7.8 a	8.0 a

The averages that have at least one common alphabet in each column according to the Tukey test at 1% probability level do not have a significant difference.

1.Number of Leaves

The results of variance analysis of data showed that simple effect of nutritional treatments and simple effect of cultivar on number of saintpaulia leaves was significant at 1% probability level (Table 1). The mutual effect of cultivar and nutrition was also significant at 1% probability level (Table 1). The results of mean comparison of data also showed that the highest number of leaves was observed in complete solid fertilizer treatment and in Optimara cultivar with a mean of 16.4 leaves, and after that, the highest number of leaves was observed in complete liquid fertilizer treatment and in Optimara cultivar with an average of 15.4 leaves and then in complete solid fertilizer treatment and in Rhapsody cultivar, which did not show any significant difference with other treatments. The lowest number of leaves was observed in complete liquid fertilizer treatment and in Rhapsody cultivar with a mean of 10 leaves, which showed no significant difference with complete high phosphorous fertilizer treatment and Optimara cultivar, but had a significant difference with other treatments (Fig 1).

Plants need to have the right proportions of different nutrients for optimal vegetative growth, and complete fertilizers, by providing the essential elements of nitrogen, phosphorous, and potassium, increase the growth and number of leaves in the plant. These results are in consistent with the results of Abedini (2015) on the Geraniums.

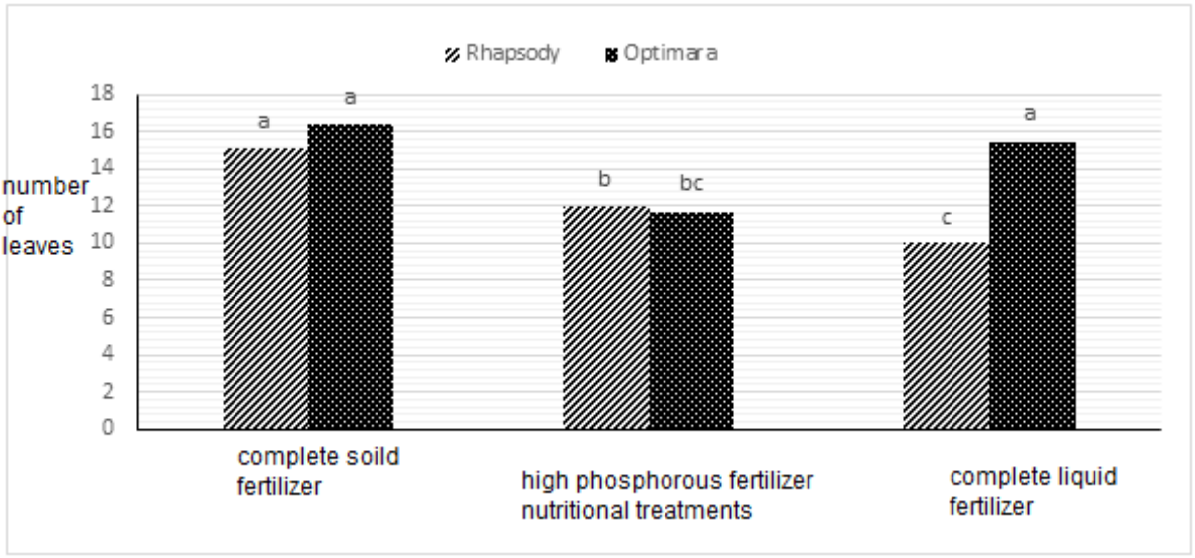

Figure 1. The Mutual Effect of Nutrition and Cultivar on the Average of Saintpaulia Leaves

2. Number of Flowers

The results of variance analysis of data showed that simple effect of nutritional treatments and simple effect of cultivars on number of saintpaulia leaves was significant at 1% probability level (Table 1). The results of mean comparison of data showed that the highest number of flowers was found in Optimara cultivar and in high phosphorous fertilizer treatment with an average of 26.8 flowers, which had a significant difference with other nutritional treatments**.** Thelowest number of flowers was observed in complete solid fertilizer treatments and Rhapsody cultivar with an average of 11.6%, which showed a significant difference with other treatments (Fig. 2).

Using phosphorous fertilizer leads to root development, increasing nutritional absorption of the plant, and consequently increasing photosynthesis and improving weightin plant organs, which will increase the number of flowers in plants by influencing the flowering. These results are in consistent with the results of Abedini et al. (2015) on geraniums.

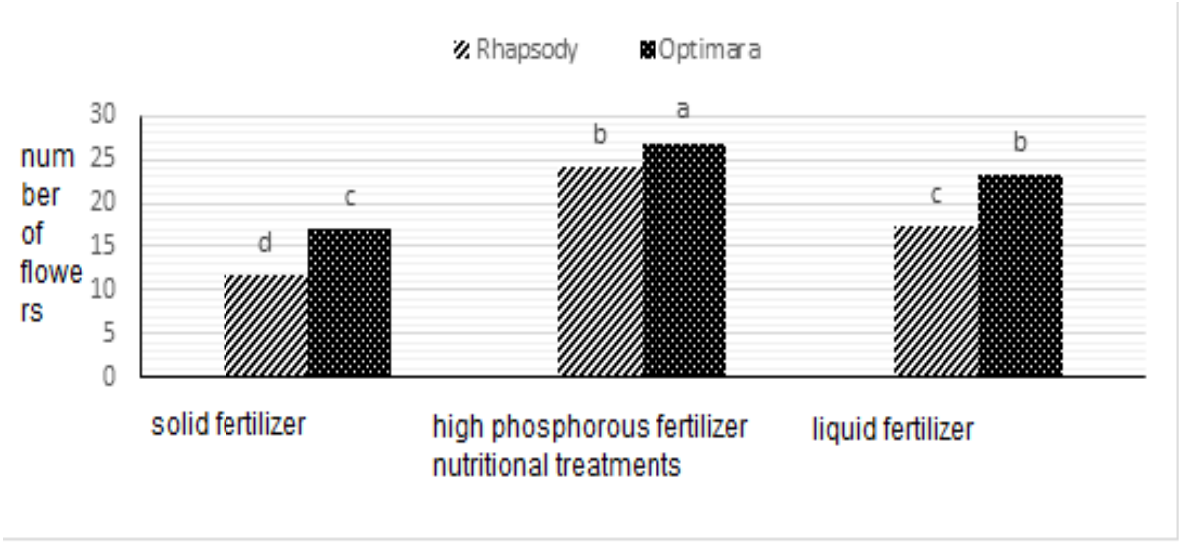

Figure 2. The Mutual Effect of Nutrition and Cultivar on the Average Number of Saintpaulia Flowers

3.Number of Buds

The results of variance analysis of data showed that simple effect of nutritional treatments and simple effect of cultivar on the number of saintpaulia buds were significant at 1% probability level. The mutual effect of cultivar and nutrition was significant at 5% probability level (Table 1). The results of mean comparison of data also showed that the highest number of buds was observed in high phosphorous fertilizer treatment in Optimara cultivar with an average of 28.8 buds, which had a significant difference with other buds. The lowest number of buds was observed in solid fertilizer treatment in Rhapsody cultivar with an average of 14.1 buds (Fig. 3).

Phosphorous increases the vegetative and reproductive growth in the plant by increasing the absorption of nutrients and improving the root development of the plant. With the development of roots in the plant and improvement of reproductive growth, the number of buds will increase in the plant. These results are in consistent with the results of Amjazi and Hamidpour (2013) on common zinnia.

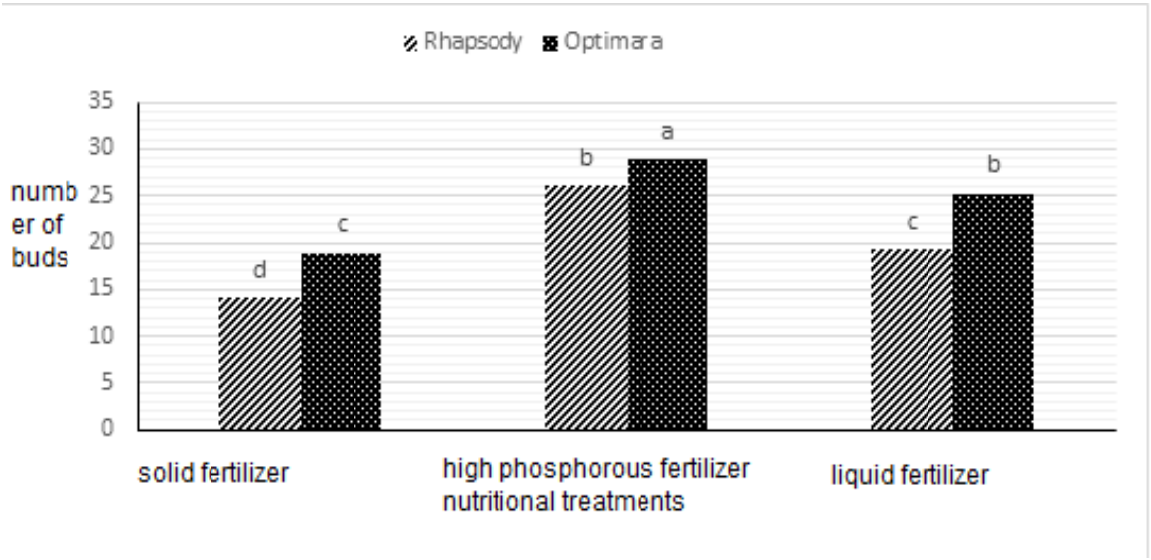

Figure 3. The mutual Effect of Nutrition and Cultivar on the Average Number of Saintpaulia Flowers

4.Number of Flowering Branches

The results of variance analysis of data showed that simple effect of nutritional treatments and simple effect of cultivar on number of flowering branches of saintpaulia were significant at 1% level. In addition, the interaction between cultivar and nutrition was not significant (Table 1). The results of the comparison of the data mean in the study of simple nutrition effect indicate that the highest number of flowering branches was observed in high phosphorous fertilizer treatment with an average of 6.2, which had a significant difference with other nutritional treatments. The lowest number of flowering branches was observed in solid fertilizer treatment with an average of 4.4, and then liquid fertilizer treatment with an average of 4.6, which had a significant difference with other treatments (Table 2).

Increasing the absorption of nutrients by applying phosphorous and creating proper growth conditions and the effect of these compounds on the macronutrients and improving the physical and chemical conditions of the beds will increase the number of flowering stems in this plant. These results are in consistent with the results of Abedini at al. (2015) on geraniums.

5.Number of Days to Flowering

The results of variance analysis of data showed that simple effect of nutritional treatments on days to flowering of saintpaulia was significant at 1% level. The simple effect of cultivar in days to flowering was significant at 5% probability level. However, the interaction effect of cultivar and nutrition did not significantly affect the number of days to flowering (Table 1). The results of comparison of the data mean also showed that the highest number of days to flowering was observed in solid fertilizer treatments and in Rhapsody cultivar with an average of 58.86 days to flowering that with this fertilizer treatment in Optimara cultivar and liquid fertilizer treatment in two cultivars did not have any significant differences. The lowest number of days of flowering was observed in high phosphorous fertilizer treatments and in Rhapsody cultivar that with this fertilizer treatment in Optimara cultivar did not have any significant difference in number of days to flowering (Fig. 4).

Proper proportions of essential nutrients such as potassium, phosphorous and especially nitrogen, which is very effective in increasing vegetative growth, can increase the vegetative growth rate in the plant. As the vegetative growth of the plant grows faster, the plant completes its life cycle faster and it enters the reproductive phase earlier, therefore the number of days to flowering decreases. These results are in consistent with the results of Amjazi and Hamidpour (2013) on common zinnia.

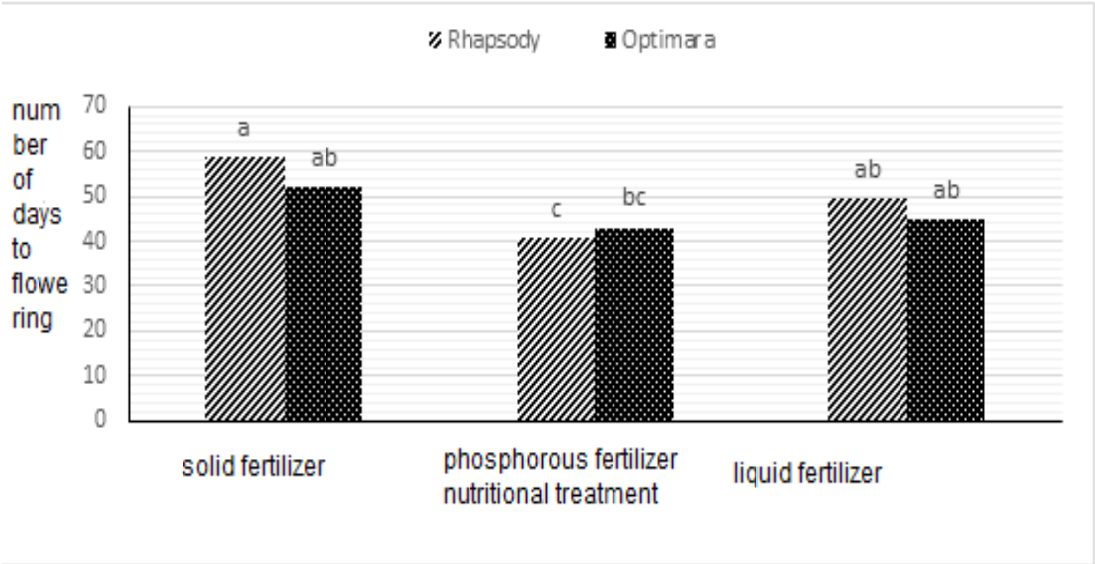

Figure 4. The Interaction Effect of Nutrition and Cultivar on the Average number of Days to Flowering of Saintpaulia

6.Flower Longevity

The results of data variance analysis showed that simple effect of nutritional treatments on the viability of saintpaulia was significant at 5% probability level. The simple effect of cultivar on flower longevity was significant at 1% probability level. However, the interaction effect of cultivar and nutrition did not significantly impact the flower longevity (Table 1). The results of the comparison of data mean in the study of the effect of nutrition showed that the maximum level of flower longevity was observed in liquid fertilizer treatment with an average of 6.2 days, which had a significant difference with other fertilizer treatments. The lowest level of flower longevity was observed in high phosphorous fertilizer treatment with an average of 4.2 days. However, there was no significant difference between this treatment and solid fertilizer treatment with an average of 4.9 days in terms of flower longevity (survival) (Table 2).

The results of the comparison of data mean in evaluating the effect of the cultivar showed that the highest flower longevityin liquid fertilizer was observed in Rhapsody cultivar with an average of 4.5 days, which had a significant difference with other cultivars. The lowest survival time was observed in Optimara with an average of 7.4 days, which had a significant difference in flower longevity with other cultivar (Table 3).

Phosphorous with proper development of the root increases the growth rate and makes earlier the process of ripening and aging of the plant. This can reduce the flower longevity of the plant. These results are in consistent with the results of Amjazi and Hamidpour (2013) on common zinnia.

7.Flower Diameter

The results of data variance analysis showed that the simple effect of nutrition and the simple effect of cultivar on diameter of saintpaulia was significant at 1% probability level. The interaction effect cultivar and nutrition did not significantly affect flower longevity (Table 1). The results of the mean comparison of the data also showed that the highest flower diameter was observed in high phosphorous fertilizer with a mean of 2.4 cm, which had a significant difference with other fertilizer treatments. The lowest flower diameter was observed in solid fertilizer treatment with an average of 1.7 cm. However, there was no significant difference between this treatment and liquid fertilizer treatment with an average of 1.9 cm in terms of flower diameter (Table 2).

The results of mean comparison of data showed that the highest flower diameter was observed in Rhapsody cultivar with a mean of 2.3 cm, which had a significant difference with other cultivars in flower diameter. The lowest flower diameter was found in Optimara with an average of 1.8 cm, which had a significant difference with the other cultivar (Table 3).

Phosphorous improves the growth of the plant by providing nutrients for the root of the plant, thereby increasing the growth in flowers and, consequently, increasing the flower diameter in the plant. These results are in consistent with the results of Tabatabaei et al. (2015) on Echium amoenum.

8. Leaf Area

The results of data variance analysis showed that simple effect of nutritional treatments and simple effect of cultivars on the leaf area of saintpaulia were significant at 1% probability level. The interaction between cultivars and nutrition was also significant at 1% probability level (Table 1). The results of the mean comparison of data showed that the highest leaf area was observed in solid fertilizer treatment and a Rhapsody with a mean

of 1.9 cm^2,which had a significant difference with other treatments. The lowest leaf area was found in high phosphorous fertilizer treatment and Rhapsody cultivar with an average of 4 cm^2. However, there was no significant difference between this treatment and complete liquid fertilizer and in Rhapsody cultivar with an average of 4.2 cm^2 and solid fertilizer treatments and in Optimara cultivar with an average of 4 cm^2 there was no significant difference (Fig. 5).

A good proportion of essential nutrients will increase the vegetative growth, and then the leaf area of the plant. These results are in consistent with the results of Amjazi and Hamidpour (2013) on common zinnia and Tabatabaei et al. (2015) on Echium.

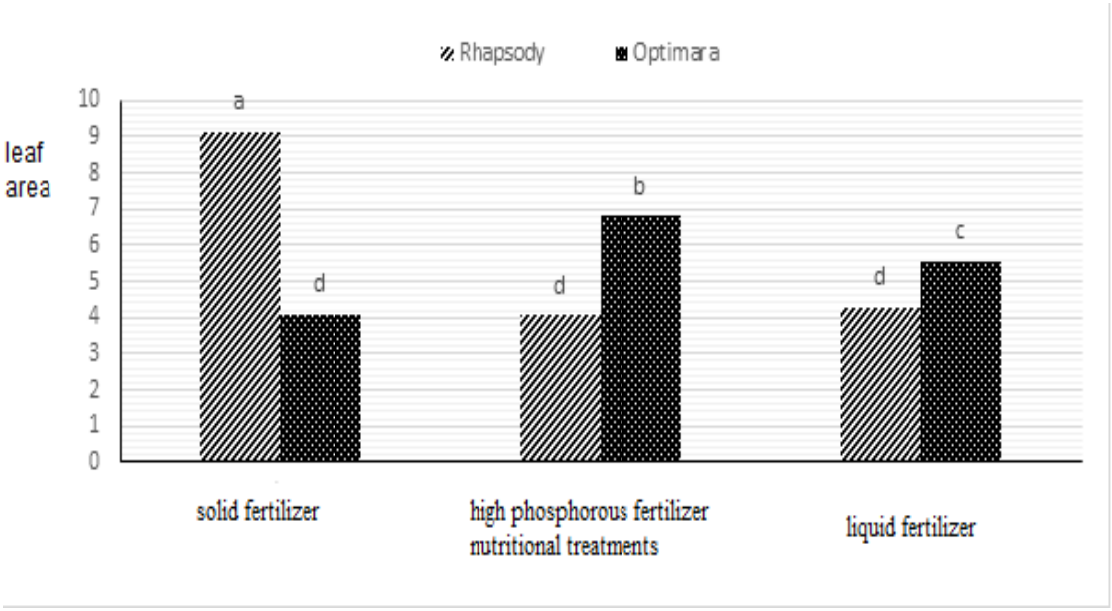

Figure 5. The Interaction between Nutrition and Cultivar on the Average of Saintpaulia Leaf Area

9.Root Dry Weight

The results of data variance analysis showed that simple effect of nutritional treatments and simple effect of cultivar on root dry weight of saintpaulia were significant at 1% probability level. The interaction between cultivars and nutrition was not significant (Table 1). The results of comparison of the data mean in the study of the effect of simple nutrition showed that the highest root dry weight was observed in high phosphorous fertilizer treatment with an average of 3.6 g, which had a significant difference with other fertilizer treatments. The lowest root dry weight was observed in solid fertilizer treatments with an average of 7.2 g, which had a significant difference with other fertilizer treatments (Table 2).

The results of comparing the data mean on evaluating the effect of simple cultivar on root dry weight showed that the highest root dry weight was observed in Optimara with an average of 3.4 g, which had a significant difference with other cultivars. The lowest root dry weight was observed in Rhapsody with an average of 3 g, which had a significant difference with other cultivars (Table 3).

The existence of phosphate in the root environment has led to the improvement and enhancement of the available nutrients around the root, which can be considered as a factor for the improvement and development of the roots of the plants. These results are in consistent with the results of Ghamari et al. (2015) on the Brompton Stock.

10. Number of Flowers in Inflorescences

The results of data variance analysis showed that simple effect of nutritional treatments on flower number in saintpaulia inflorescence was significant at 1% probability level. The simple effect of cultivar, as well as the interaction between cultivar and nutrition was significant at 1% probability level (Table1). The results of the mean comparison of the data also showed that the highest number of flowers in inflorescence was observed in high phosphorous fertilizer treatment and Rhapsody cultivar with an average of 4.6 numbers, which did not have any significant difference with high phosphorous fertilizer treatment in another cultivar and also liquid fertilizer treatment in both cultivars. The lowest number of flowers in inflorescence was observed in solid fertilizer treatment and Rhapsody cultivar with an average of 3.2 numbers, which did not have any significant difference with solid fertilizer treatments in another cultivar, but it had a significant difference with other treatments (Fig. 6).

Increasing plant reproductive growth by phosphorous can be justified in two ways. First, phosphorous increases the number of flowering branches in the plant and also increases the number of flowers in the inflorescence. These results are in consistent with the results of Abedini et al. (2015) on geraniums.

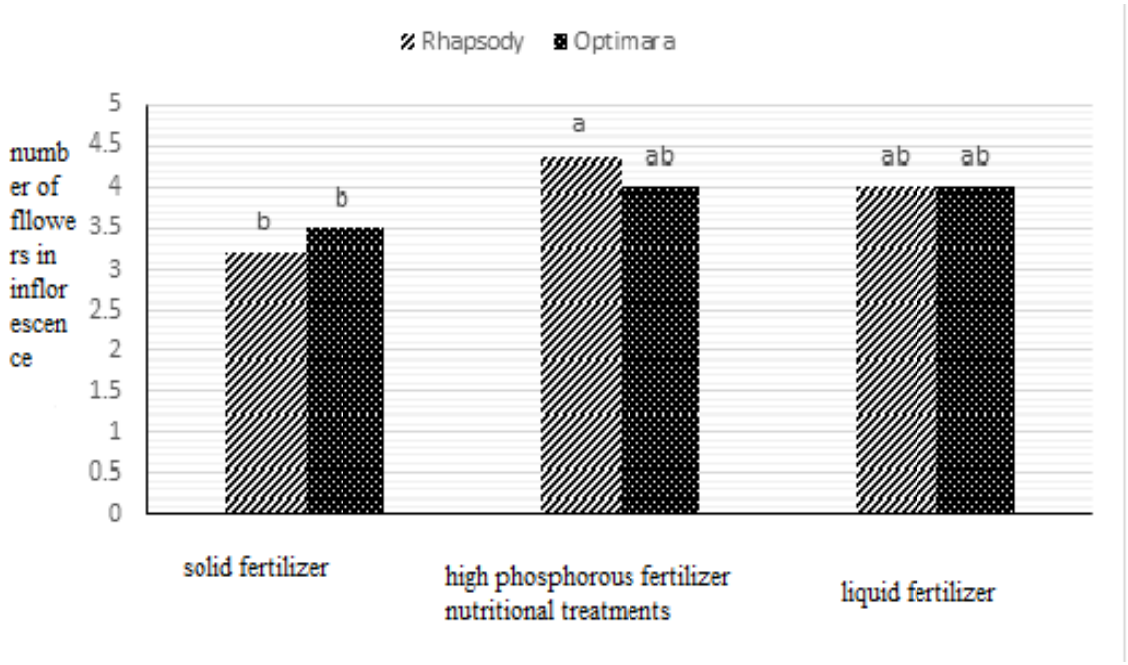

Figure 6. The Interaction between Nutrition and Cultivar on the Average Number of Flowers in Saintpaulia Inflorescence

11.Flowering Period

The results of data variance analysis showed that simple effect of nutritional treatments of saintpaulia flowering period was significant at 1% probability level. The simple effect of cultivar, as well as the interaction between cultivar and nutrition was significant at 1% probability level (Table 1). The results of the mean comparison of the data also showed that the highest flowering period was observed in complete liquid fertilizer treatment and in Rhapsody with an average of 34.8 days, which did not have any significant difference with other treatments. The lowest flowering period was observed in solid fertilizer treatment and in Rhapsody with an average of 12.1 days, and then high phosphorous fertilizer treatment was observed in Optimara, which had a significant difference with other fertilizer treatments (Fig. 7).

The proper ratio of essential nutrients for the optimal growth of Saintpaulia is importantso that high ratio of phosphorous increases the process of growth and flowering in the plant, and as a result, the plant will complete its life cycle earlier and its flowering period will be completed sooner. These results are in consistent with the results of Amjazi and Hamidpour (2013) on the common zinnia.

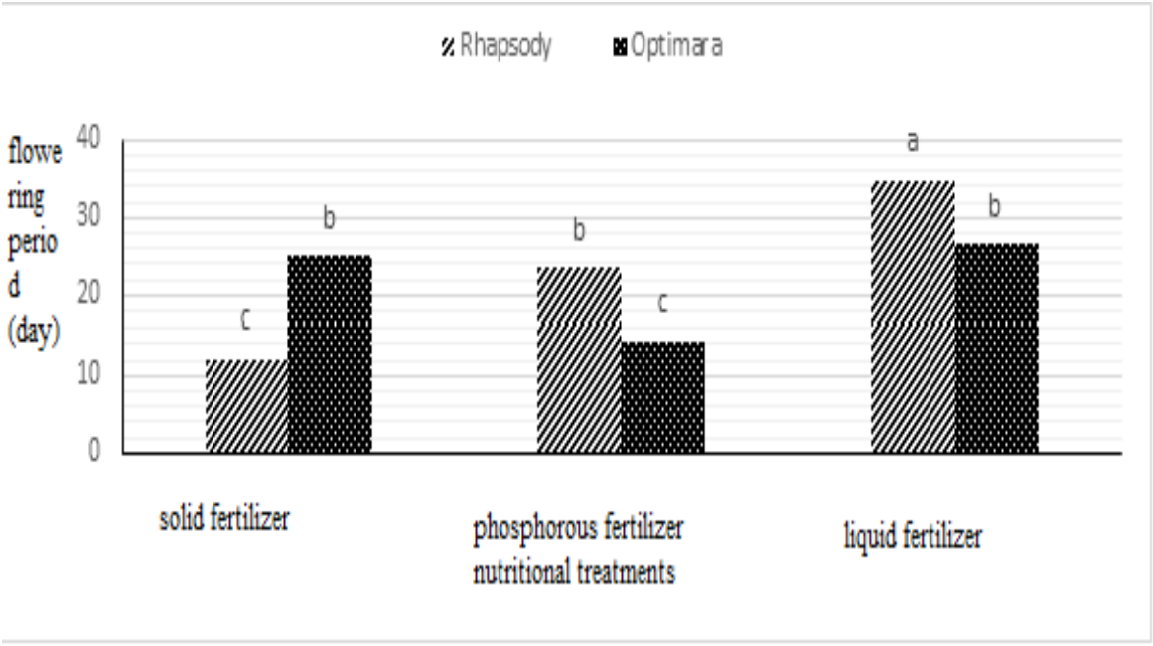

Figure 7. Interaction of Nutrition and Cultivar on Average Flowering Period of Saintpaulia

12.Distance between Flowering Periods

The results of data variance analysis showed that simple effect of nutritional treatments on the interval between saintpaulia flowering periods was significant at 1% probability level. Simple effect of cultivar was also significant at 5% probability level and the interaction between cultivars and nutrition was also significant at 1% probability level (Table 1). The results of the mean comparison of the data also showed that the maximum interval of flowering periods was observed in the treatment of complete liquid fertilizer treatment and in Rhapsody cultivar with an average of 31 days, which had a significant difference with other treatments. The lowest difference was observed between flowering periods in high phosphorous fertilizer treatment and in Optimara cultivar with an average of 14.6 days (Fig. 8).

Phosphorous reduced the period of seedlings by increasing the growth rate of the plant and with completion of vegetative growth, the plant enters the reproductive phase. Therefore, the distance between flowering periods in the saintpaulia decreased. These results are in consistent with the results of Abedini et al. (2014) on geraniums.

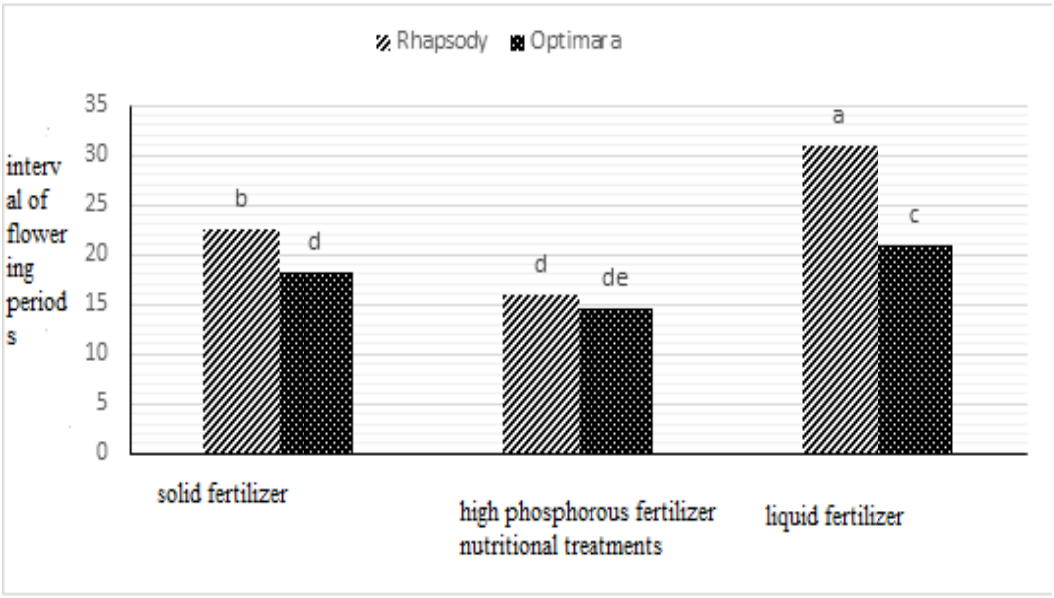

Figure 8. The Interaction between Nutrition and Cultivars on the Average Distance between Saintpaulia Flowering Periods

13.Bush (Plant) Height

The results of data variance analysis showed that the simple effect of cultivar and the simple effect of nutrition, and also the interaction between cultivars and nutrition were significant at 1% probability level (Table 1). The results of mean comparison of data also showed that the highest level of plant (bush) height was observed in solid fertilizer treatment and in Rhapsody cultivar with an average plant (bush) height of cm, which had a significant difference with other treatments. The lowest plant height was observed in solid fertilizer treatments in cultivar that did not show significant difference with the complete liquid fertilizer in the same cultivar, but had a significant difference with other treatments (Fig. 9).

High levels of nutrients in planting beds, along with using fertilizer compositions, have led to stimulation of vegetative growth and enhancement of plant water absorption. Furthermore, optimal preparation of high and low nutrient elements with the presence of organic materials resulted in improvement of photosynthesis and subsequently an increase in the plant height and growth. These results are in consistent with the results of Amjazi and Hamidpour (2013) on common zinnia.

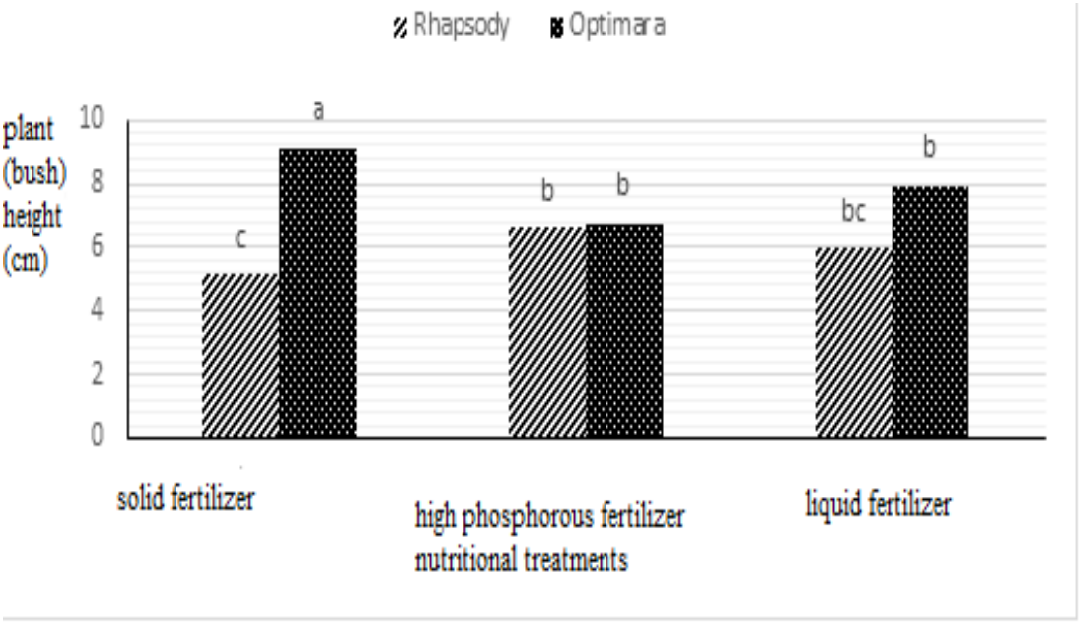

Figure 9. The Interaction between Nutrition and Cultivars on the Average Distance between Saintpaulia Flowering Periods

14.The Length of Inflorescence

The results of data variance analysis showed that the simple effect of nutritional treatments and simple effect of cultivar on the length of saintpaulia inflorescence was significant at 1% probability level. The interaction between cultivars and nutrition was also significant at 1% probability level (Table 1). The results of mean comparison of the data also showed that the highest inflorescence length was observed in solid fertilizer treatments in Rhapsody cultivar with an average of 9 cm, which had a significant difference with other fertilizer treatments. The lowest inflorescence length was observed in high phosphorous fertilizer treatment and in Optimara cultivar with a mean of 1.7 cm that the complete liquid fertilizer did not have a significant difference in the same cultivar, but had a significant difference with other fertilizer treatments (Fig. 10).

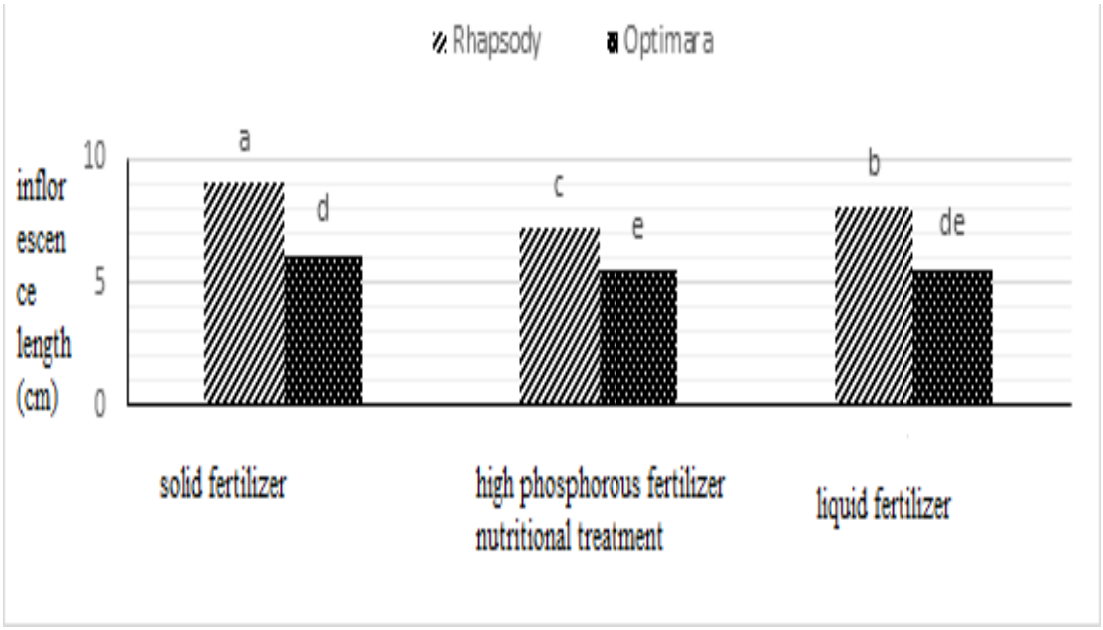

Figure 10. The Interaction between Nutrition and Cultivar on the Average Length of Saintpaulia Inflorescence

According to the results of nutrition, regarding the application of phosphorous fertilizer, it can be said that the cultivation of this plant in a bed with suitable porosity and then using phosphorous fertilizers greatly improves the characteristics of growth and flowering in this plant, so that most of the growth and flowering features in this plant were better than those that did not use a high ration of phosphorous fertilizer, but in traits such as flowering longevity and flowering period, liquid fertilizer treatment acts better.

Conclusion

In general, saintpaulia due to its fine (small) root system, requires light bedding with a good ventilation porosity and drainage. Therefore, Peat moss planting bed: Perlite with the lowest density and the greatest porosity of ventilation is very suitable for vegetative and reproductive growth of this plant, so that all the measured traits in this bed have the best values compared to other beds.

Regarding plant nutrition, using solid fertilizer can improve the plant (bush) growth and improve plant flowering, but phosphorous fertilizer can increase the flowering rate and speed of flowering in the plant. In addition to these two types of fertilizers, the liquid fertilizer has the best values in most of the measured traits of the plant, so that, in terms of the beauty of the plant and proper form of the plant, the liquid fertilizer works better and creates a longer flowering period for the plant.

References

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