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The Impact of Ecologic Factors on Growth and Development of Two Polygonatum Species

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Abstract

The research results of environment impact on growth and development of *Polygonatum odoratum* (Mill.) Druce and *Polygonatum severtzowii* Regel species are given in the article. The effect of light intensity, temperature and humidity factors was noted in the studied species.

Keywords

Polygonatum odoratum (Mill.) Druce, *Polygonatum severtzowii* Regel, Growth, Development, Environment Factors, Tashkent Botanical Garden

1. Introduction

Polygonatum (Asparagaceae) is a widespread temperate genus with approximate 75 species distributed throughout the temperate Northern Hemisphere, centered in the Eastern Himalaya and Indo-Burma biodiversity hotspots [1].

At least 37 species and 1 variety of Polygonatum plants have been used as traditional medicine and functional food. The major chemical constituents of Polygonatum plants are steroidal saponins, triterpenoid saponins, homoisoflavanones, polysaccharides and lectins. The medicinal plants of Polygonatum have been traditionally used as tonics in China, India, Pakistan, Iran and Japan, and have been demonstrated to be highly effective in clinical practice for treating age-related diseases, diabetes, lung diseases, fatigue, feebleness and indigestion [2]. That's why introduction of valuable medicinal plants to local conditions is of great significance both from theoretical and practical point of views. *Polygonatum odoratum* (Mill.) Druce and *P. severtzowii* Regel are widely employed in medicine and horticulture. Introduction and development of scientifically based methods of growing and breeding of *P. odoratum* (Mill.) Druce studied by foreign scientists and *P. severtzowii* Regel growing in the local mountainous re-

gions are very important.

Plants growth and development are interconnected processes, producing under the effects of heredity (genotype) and environmental factors. Interrelation of genetic and environmental factors is also determined by seasonal term of plants growth and development.

There are various factors' effects on plants growth and development under nature conditions.

Due to the fact that natural resources of medicinal plants are limited, in the future, the requirements of pharmaceutical industry in raw materials of medicinal plants increasing and its production can be met mainly by growing on plantations. Increasing the number of medicinal plants species used in the drugs production is one of the most important scientist's tasks. So, the introduction, reproduction and cultivation of endemic, endangered and value medicinal plants belong to outside origin plants, also the plant of local flora can solve this problem.

Till now no studies were conducted on specific features of these rare species under Uzbekistan conditions [3].

The purpose of this work is an exploration of environmental factors affecting on growth and development of two species of *Polygonatum* genus under Tashkent conditions.

2. Object and Methods of the Research

Experiments were conducted in the exposition of the laboratory of Tashkent botanical garden of the Academy of Sciences of Uzbekistan, The soil in the experimental plot is salt-free serozem, by granulometric composition it is sandy soil. The Botanical garden locates at 473 m above sea-level (41˚20'38" north latitude, 69˚18'55" east longitude), the level of underground water is 5 - 6 m. The climate of the territory is sharply changeable, subtropical. It is characterized by hot, dry summer and changeable, but generally warm, autumn-winter-spring weather. So it doesn't strong differ from soil-climatic conditions of the origin growth area of introducentes.

Objects of research are flowering plants, family Asparagaceae: *Polygonatum odoratum* (Mill.) Druce native to Europe, the Caucasus, Siberia, the Russian Far East, China, Mongolia, Korea and Japan; *Polygonatum severtzowii* Regel distributed in Central Asia, 800 - 200 m above sea level. *P. severtzowii* Regel in our research experiment were taken from Ugam-Chatkal mountains, Bostanlyk district.

The study of the biomorphological characteristics: height, diameter of stem; number, length, width of cauline leaves; length, diameter of rhizome are carried out by generally conventional methods [4]-[9]. Phenological observations in (light, soil temperature, relative air humidity, air temperature) were conducted during three years period, ones per day in the spring season and every five days in the summer season. Statistical data analysis is obtained basing Zaitsev G.N. method.

3. Results and Discussion

The growth and development index were taken as criteria for bioecological features' study of studied plants. According to the research results, the morphological characteristics of Solomon's seal plant planted in two experimental plots differed significantly.

So, the effect of the light intensity on the morphological character of *P. odoratum* is shown the following parameters: stem 11.5 cm tall in average, leaves number 5, rhizomes 9.2 cm long, and 11.0 mm in diameter; vegetation duration is 130 days.

P. severtzowii grown in the same plot has very short vegetation duration (35 days), stem 5.2 cm tall in average, leaves number 1.1 in average, rhizome 9.5 cm long, 18.0 mm in diameter.

The growth intensity, leaves number and number of cropped plants growing under shady conditions are higher comparing with plants growing in a sunny plot, thus, the stem of *P. odoratum* 23.7 cm tall in average, leaves number 8.0 in average, 3.1 cm wide, 8.2 cm long, rhizome 14.5 cm long and 13.5 mm in diameter. *P. severtzowii* species are 14.5 cm; 1.3; 1.8 cm; 7.4 cm; 10.8 cm, 24.3 mm accordingly (Table 1).

The plants, growing under sunny conditions that had shorter vegetation period, were stunted, with thin and fragile stem, smaller leaves, pale-green stem and leaves. The plants grew under shadowy conditions with higher, thicker stem, bigger and dark-green leaves.

So, it was defined that for studied species Solomon's seal, the high light intensity negatively impacts on its grow and development process.

It was determined that the effect of air temperature depends on plants development phase.

Thus, first vegetation year of *P. odoratum*, from germinating to budding stages 18 days, at air temperature 15.2˚C in average, on the second vegetation year the same vegetation period 17 days in average, at air temperature 11.4˚C, on the third vegetation year, this period was 16 days, at 11.6˚C (Table 2).

Consequently, simultaneous temperature rising till definite level increases the intensity of plants development. Based on this fact, the period from the beginning of plant appears on the soil surface till budding stage is shortened (Table 2).

Table 1. The effect of light intensity on plants growth.

Plants	Cropping variants	Stem		Cauline leaves			Rhizome	
		Height, cm	Diameter, mm	Number	Length, cm	Width, cm	Length, cm	Diameter, mm
P. odoratum	Shadow	23.7 ± 0.7	6.0 ± 0.2	8.0 ± 0.3	8.2 ± 0.5	3.1 ± 0.5	14.5 ± 0.9	13.5 ± 0.4
	Sunny	11.5 ± 0.4	4.0 ± 0.3	5.0 ± 0.1	5.6 ± 0.4	2.5 ± 0.6	9.2 ± 0.7	11.0 ± 0.3
P. severtzowii	Shadowy	14.5 ± 1.5	6.0 ± 0.3	1.3 ± 0.4	7.4 ± 0.1	1.8 ± 0.1	10.8 ± 1.1	24.3 ± 0.4
	Sunny	5.2 ± 0.4	4.5 ± 0.2	1.1 ± 0.2	4.1 ± 0.1	0.5 ± 0.6	9.5 ± 0.3	18.0 ± 0.3

Table 2. Factors of microclimate condition in plants introduction.

Vegetation year	Months	Light, th/lux	Air temperature, ˚C	Relative air humidity, ˚C	Soil temperature, ˚C
	III	42.0	15.2	48.0	9.9
	IV	53.3	16.8	55.0	12.4
	V	45.0	23.2	47.0	19.0
1	VI	39.7	28.1	32.0	25.2
	VII	39.5	29.1	34.0	21.7
	VIII	38.7	27.7	35.0	25.7
	IX	37.1	20.7	40.0	19.9
	III	49.0	11.4	60.0	8.6
	IV	52.0	12.8	72.0	8.3
	V	52.7	20.0	59.0	16.9
2	VI	54.3	24.1	46.0	21.6
	VII	45.8	27.8	34.0	22.8
	VIII	39.3	25.8	40.0	19.8
	IX	40.7	20.8	49.0	17.2
	III	47.5	11.6	60.0	8.9
	IV	44.5	17.1	62.0	12.7
	V	40.8	20.7	59.0	17.1
3	VI	38.0	25.3	53.0	20.5
	VII	39.0	27.3	39.0	22.4
	VIII	38.2	26.9	40.0	19.8
	IX	40.8	20.9	46.0	17.0

Interval from budding to flowering stage in *P. odoratum* during the first vegetation year was 14 days, at air temperature 16.8˚C, and on the second and third vegetation years this period was the same 16 days, at air temperature equaling to 12.8˚C - 17.1˚C correspondingly.

According to the indexes before flowering, from flowering till seed stages, and full maturing the weather in many cases was hot and dry. In plots with *P. odoratum* in the period from blooming till seedling and full ripening on the first vegetation year was 161 days, at air temperature 24.2˚C in average, on the second and the third vegetation year this period was 161 - 159 days, at air temperature 21.9˚C - 23.0˚C in average.

During plants introduction it was also necessary to pay attention to relative air humidity. The stem height of *P. odoratum* on the first vegetation year reached to 22.5 ± 0.51 cm on average, at 51.0% relative air humidity; on the second vegeta-

tion year the stem height reached 24.2 ± 0.43 cm in average, at 65.5% and relative air humidity in average On the third vegetation year the stem height was 24.5 ± 0.68 cm, at 60.5% correspondingly. It was noted that these indexes in *P. severtzowii* changed for 13.2 ± 0.58 cm and 21.4 ±1.59 cm or for 55.0% and 72.0% accordingly (Table 2).

The indexes of relative air humidity in plot with *P. odoratum* were higher comparing with *P. severtzowii. P. odoratum* stem was strong, intensively growing, with foliage surface, rather larger than in *P. severtzowii.* All these facts were the reason of relative air humidity's change in a sensible degree in plots.

The decrease of relative air humidity in June-July, after seeds ripening, exercised special impact. Thus, an air temperature in this period comparing to spring season was high, in a sensible degree and relative air humidity was very low. It was observed that in summer period an air temperature is most high and relative air humidity is low, so the intensity of seeds ripening is accelerating.

The soil temperature and humidity play an important role in plants growth and development.

According to conducted research works, on the first vegetation year in May the rhizomes began to appear on the soil surface, at 9.9˚C soil temperature on average. On the second and the third vegetative years rhizomes began to grow at 8.6˚C - 8.9˚C.

The intensity of stem growth in introducens, the appearance of additional roots are directly connected to soil temperature. As far as high soil temperature, so the intensive of stem growth and quite the reverse as far as soil temperature low, so late growth rootstem and development also become slower. Than higher the soil temperature, the more intensive stock growth, and contrary, than the lower soil temperature, so the stock growth and plant development is late and slows down.

Experiments have shown that the duration of the generative phases in plants requires a different time. The reason is that the air temperature, relative humidity and soil temperature are various at stages. As the climatic parameters increase, the stages duration decrease.

That is, on the first vegetative year budding stage was 21 days, flowering stage 19 days; fruit maturation 142 days. On the second and third vegetation years budding stage was 21 - 20 days, blooming stage 18 - 19 days, fruit ripening stage 144 - 142 days.

Thus, the maximum level of soil temperature in the area around plant corresponds to the fruits formation stage and partly on the maturation stage.

In plots with *P. odoratum* and *P. severtzowii* on the first year high index of soil humidity was in April, 18.5% in average. At that time, in *P. odoratum* the rhizomes raw weight was 5.63 g and dry weight 0.99 g. In *P. severtzowii* 17.l1 g and 3.33 g correspondingly, low index was shown in June 12.3% in average. in *P. odoratum* raw weight of rhizome was 6.58 g, dry weight 1.27 g, in *P. severtzowii* raw weight of rhizome was 18.0 g, dry weight 3.49 g. On the second vegetation

year a maximal index of soil humidity was in March reaching 16% in average. Raw weight of rhizome in *P. odoratum* was 12.1 g, dry weight 2.17 g. Raw weight of rhizome in *P. severtzowii* was 19.3 g, dry weight 3.53 g, maximal index of soil humidity was in June 9.2% in average. In *P. odoratum* raw weight of rhizome was 14.8 g, dry weight 2.63 g, in *P. severtzowii* raw weight 20.2 g, dry weight3.63 g. On the third vegetation year soil humidity and temperature indexes were 15.8% - 10.4% accordingly and in *P. odoratum* 24.5 - 4.41 g and 27.7 - 5.09 g, in *P. severtzowii* 23.0 - 4.37 g and 23.8 - 4.56 g (Table 3 and Table 4).

Thus, the growth, development and way of vegetation are depending on conditions and weather factors that revealed the resistance of plants to cold and drought. The experimental results show that the average soil moisture index during seasonal periods and vegetation years influences on the leaves and stems growth, entire plant, rhizomes and on the formation of additional roots.

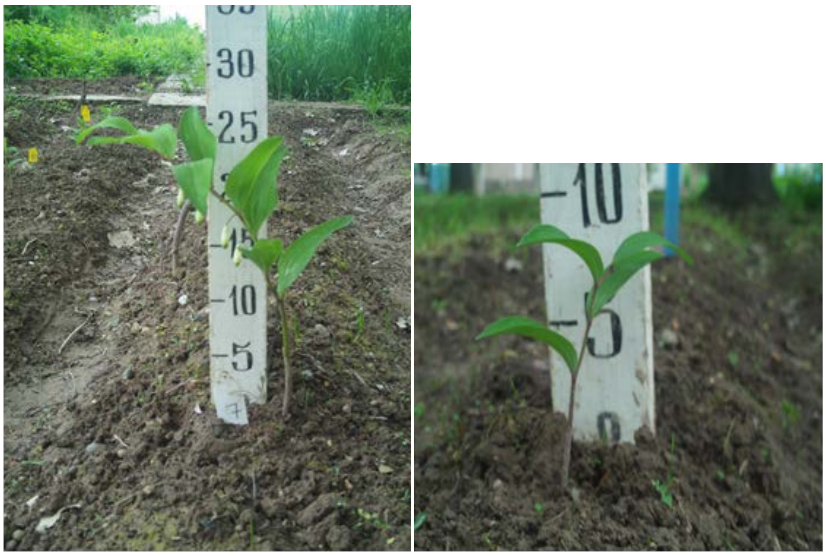
Table 3. Dependence of *P. odoratum* morphobiological characters on soil temperature during vegetation period.

Vegetation years	Budding stage			Flowering stage			Fruit ripening stage	
	Soil temperature, ˚C	Stem height, cm	Rhizome length, cm	Soil temperature, ˚C	Stem height, cm	Rhizome length, cm	Soil temperature, ˚C	Rhizome length, cm
1	12.4	15.8 ± 0.66	10.4 ± 0.38	15.7	29.4 ± 0.50	11.2 ± 0.45	19.9	14.5 ± 0,
2	8.3	17.1 ± 0.27	9.1 ± 0.57	12.6	31.7 ± 0.39	10.2 ± 0.23	17.2	13.7 ± 0,
3	12.7	15.2 ± 0.40	8.7 ± 0.81	14.9	29.0 ± 0.48	9.7 ± 0.40	17.0	12.8 ± 0,

Explanation: In flowering stage the growth length is stopped and it stays nearly same during the vegetative period. Therefore the stems height is not demonstrated at the fruiting stage. (Figure 1 and Figure 2).

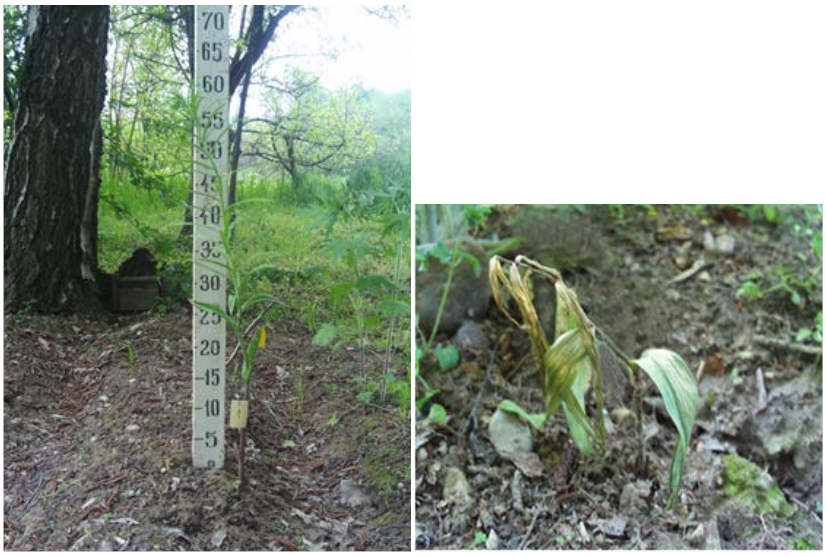
Table 4. Soil humidity in the experimental plots.

Years	Soil depth, cm	Months						
		March	April	May	June	July	August	September
1	0 - 10	16.3	19.9	17.5	10.2	13.9	12.8	14.6
	10 - 20	16.7	18.7	16.5	12.4	14.7	11.7	15.2
	20 - 30	17.6	17.1	17.1	14.2	14.0	13.5	10.9
	average	16.8	18.5	17.0	12.3	14.2	12.6	13.5
2	0 - 10	16.9	8.5	7.5	8.9	7.0	7.7	10.0
	10 - 20	15.8	13.2	11.4	9.1	10.2	8.9	10.4
	20 - 30	15.1	17.0	15.9	9.8	11.7	9.8	12.3
	average	16.0	13.0	11.6	9.2	9.6	8.8	11.0
3	0 - 10	12.2	15.3	12.7	10.2	9.2	10.5	12.5
	10 - 20	15.3	15.7	15.5	11.9	9.8	11.7	13.0
	20 - 30	16.9	16.5	17.1	13.2	12.2	13.5	17.7
	average	14.8	15.8	15.1	11.7	10.4	12.0	14.4



(a) (b)

Figure 1. Breeding *P. odoratum* under different ecological conditions ((a) shadow, (b) sunny).



(a) (b)

Figure 2. Breeding *P. severtzowii* under different ecological conditions ((a) shadow, (b) sunny).

Thus, according to the obtained results, suitable microclimate conditions in the field, shows the positive impact on growth and development activity, and opposite, unsuitable climatic conditions show negative impact on growth and development activity.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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