ECOLOGIA BALKANICA
2014, Vol. 6, Issue 1 June 2014 pp. 19-23

Response of Subalpine Saplings to Different Drought Stress

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Abstract. The expectations for increasing periods of drought are becoming larger according to numerous authors. The susceptibility of subalpine tree species to drought provoke our interest to try to understand what will be their reaction to this natural climate change. For this purpose it is set experiment to determine the reaction of drought to 4 subalpine species – Norway spruce (*Picea abies* L.), Mountain pine (*Pinus mugo* Turra), Macedonian pine (*Pinus peuce* Grisebach) and Bosnian pine (*Pinus heldreichii* H . Christ). Different requirements are observed to imitate field conditions as close as possible. The saplings are taken from terrain with no disturbed soil substrate. The plants were placed in a 15 l container and at the beginning of the vegetation were situated in a specially built greenhouse. Precipitation regime is controlled by the irrigation system. The indicators for precipitation levels (for a drought from June to July and August scheme) were taken from the two previous real years, who had a significant influence on the species. Precipitation norm for control is taken from subalpine zone of the Rila Mountain. To determine the reaction of all the groups of saplings subjected to various circuits, at the end of the year is recorded the survivors.

Key words: drought stress, subalpine saplings, precipitation regime, climate change

Introduction

In the recent years, there has been great concern about the future sustainability of subalpine ecosystems in relation to the predicted climate changes (PEREIRA *et al.*, 2006; VINER *et al.*, 2006; CRAWFORD, 2008; LINDNER *et al.*, 2010). The great interest in future responses of these forests on climate change is due to the sensitivity of subalpine tree species to drought (ADAMS & KOLB, 2005), and the high probability of increased frequency and duration of drought in many climate changes scenarios (SHEFFIELD & WOOD, 2007). A voluminous literature emphasizes the effects of environmental stresses on inhibiting plant growth and physiological processes, reducing yield of harvested plant products, and causing plant mortality. Arid conditions, which prevail over about a third of the world's land area, exclude establishment of trees; over most of the remaining land area the growth of plants, and sometimes their survival, is reduced by periodic droughts (KOZLOWSKI & PALLARDY, 2002). Plants differ widely in their capacity to cope with drought. Adaptations exist to explain these differences (PALLARDY, 2008), and these can be conveniently referenced to the capacity to maintain water status (rate of transpiration, stomatal conductance of water vapor and water potential of xylem). LETTS *et al.* (2009) observed the bimodal seasonal pattern of gas exchange in limber pine during the warm and dry growth seasons of 2006 and 2007 would likely not have occurred during cooler and wetter summers. They found that the mortality event occurred during a period

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of low precipitation during the wet seasons, which occur before and during the early portion of the growth season. Young trees are more sensitive to the drought boot of their high physiological activity and still not well established mechanisms of drought tolerance (BRÉDA *et al.*, 2006).

The aim of experiment is to determine the survivorship of young trees exposed on different water stress.

Material and Methods

The experiment was conducted in a forest nursery UOGS "G. St. Avramov" – Yundola (1350 m a.s.l.), in a specially built greenhouse, covered with blue panels of plexiglas, who transmit 26% of photosynthetically active radiation (PAR). In this way we imitate natural conditions of light typical of young tree species, who grow in (below the) canopy of a forest. It was found that on the first floor of the forest, the trees absorbed primarily in the red spectrum of PAR (associated with a relatively high amount of chlorophyll in their crowns) and under the canopy of a forest dominated the blue spectrum PAR (PALLARDY, 2008). In this reason were selected blue panels to cover the greenhouse.

In early spring of 2013, from their natural conditions of existence were taken young saplings from four subalpine tree species – Norway spruce (*Picea abies* L.), Mountain pine (*Pinus mugo* Turra), Macedonian pine (*Pinus peuce* Grisebach) and Bosnian pine (*Pinus heldreichii* H. Christ) with no disturbed soil substrate. The plants were placed in a 15 l container and at the beginning of the vegetation, were situated in the greenhouse. For check the survivorship of trees at different levels of soil moisture, the plants were divided into three groups of 40 individuals (10 from each species). To simulate the different circuits of drought was set automatic irrigation system with three rounds of irrigation. In the first of three waters regime (C), the amount of water supplied to the plants was consistent with precipitation norms at subalpine zone of Rila and Pirin Mountains (data from Climate book of Bulgaria). In the second water regime (J) are simulated rainfall amounts by 1993, characterized by drought in June and July. In the third water regime (A) are simulated rainfall amounts since 2000, characterized by drought in the second half of the summer (July-August). Specific precipitation amounts at different irrigation schemes are shown in Table 1.

In the construction of the irrigation system were using electronic programmable controllers to supply the rainfall quantity. Irrigated system were made of ½-inch polyvinyl chloride pipe with nozzle, who flowing 80 ml of water per minute for each container.

The containers were placed on the pallets with a height of 4 cm for separation from the soil moisture. For reducing penetration of sunlight, near 70% from PAR was limited with green screen around the greenhouse. Thus in the greenhouse was achieved relatively constant atmospheric humidity. The dried saplings from each tree species and from each drought regime group were numbered at the ends of July, August and September.

Results and Discussion

The number of dried saplings in July of the four tree species and three rainfall regime are shown in Table 2.

The table shows that most intense was the drying at Mountain pine – 26.7%, followed by Macedonian pine – 16.7% and Bosnian pine – 13.3%. At Norway spruce wasn't observed drying this month. From plants subjected to drought variant "J" dropped expected out most species – 20%, which is explained with the most drying conditions in this scheme of drought. Plants from irrigation scheme "C", dropped out by one species on both Macedonian pine and Bosnian pine, which can be due to stress caused by the transfer from the field.

Unlike July, August drying at the plants was considerably more intense (Table 3).

Drying of Norway spruce was most intense in August – 70% of saplings in a scheme of drought "J" and 80% of saplings in a scheme of drought "A". Intensive drying (by 70%) was observed at the Macedonian pine from the option A and at the Bosnian pine by option C. The smallest dropping was observed at Mountain pine - only one dry sapling by option A. The most intensive drying in option "A" (40%) and both 22.5% in option "C" and option "J" was observed during this month.

Table 1. Precipitation amounts (l.m^{-2}) in different regime of drought

	C	**J**	**A**
June	92.8	27.8	39.8
July	79.2	10.2	13.6
August	56.6	10.2	3.4
September	47.5	81.5	50.9

Table 2. The number of dried saplings in July

Tree species	**C**	**J**	**A**	**Total:**
Picea abies L.	0	0	0	**0**
Pinus peuce Grisebach	1	3	1	**5**
Pinus mugo Turra	1	3	4	**8**
Pinus heldreichii H.Christ	1	2	1	**4**
Total:	**3**	**8**	**6**	**17**

Table 3. The number of dried saplings in August

Tree species	**C**	**J**	**A**	**Total:**
Picea abies L.	0	7	8	**15**
Pinus peuce Grisebach	2	1	7	**10**
Pinus mugo Turra	0	0	1	**1**
Pinus heldreichii H.Christ	7	1	0	**8**
Total:	**9**	**9**	**16**	**34**

Table 4 shows that in September the most intense was the drying at Bosnian pine, which is probably due to the accumulated stress during the summer months. The largest number drop out seedlings from Bosnian pine are in a drought (A), which is explained by the delayed effect, due to low physiological activity. From the other species, Macedonian pine dry intense in September, until from the spruce saplings wasn't observed drying.

At the end of the vegetation, surviving saplings were 54 from the originally planted 120. Distribution by schemes to drought and by tree species is presented in Table 5.

From Table 5 it is apparent that the best survivorship is on Mountain pine (63 %), followed by Norway spruce (50%) and the lowest survivorship have and Bosnian pine and Macedonian pine (33%). This good survivorship of Mountain pine in the investigated schemes of drought confirms the findings of other authors for stronger negative impact on survivorship of this species, to snowless winters than hot summers (BATLLORI *et al.*, 2009). In contrast, other trees that are more affected by summer water stress have also shown mortality peaks in response to summer drought – in the Andes (CUEVAS, 2000), in the Sierra Nevada (LLOYD & GRAUMLICH, 1997) and Tibet Plateau in South China (TAYLOR *et al.*, 2006; ZHAO *et al.*, 2012; ZHAO *et al.*, 2013) found a strong negative impact to summer temperatures.

For Macedonian pine and Bosnian pine PANAYOTOV *et al.* (2010) found negative impact of summer droughts to the width of annual growth rings, which can be explained by reduced physiological activity under such extreme conditions. SCHULZE *et al.* (2005) however indicate that the strategy for the temporary reduction in the physiological activity of plants prevents death of plants, but this period should not been at the some time with the period of meristem activity.

Table 4. The number of dried saplings in September

Tree species	C	J	A	Total:
Picea abies L.	0	0	0	**0**
Pinus peuce Grisebach	1	3	1	**5**
Pinus mugo Turra	0	2	0	**2**
Pinus heldreichii H.Christ	1	1	6	**8**
Total:	**2**	**6**	**7**	**15**

Table 5. The number of surviving saplings at the end of vegetation

Tree species	C	J	A	Total:
Picea abies L.	10	3	2	**15**
Pinus peuce Grisebach	6	3	1	**10**
Pinus mugo Turra	9	5	5	**19**
Pinus heldreichii H.Christ	1	6	3	**10**
Total:	**26**	**17**	**11**	**54**

Conclusions

Our investigation shows that the best survivorship has Mountain pine. This confirms the findings of other authors for stronger negative impact of snowless winters than hot summers on survivorship of this species. Intensive drying of Norway spruce is due to his biological and ecological characteristics, related with the necessity of protection to mature forest expressed in insurance of more humid air and shaded space in the crown zone, which prevents young trees, from most intensive transpiration in drought period. The effect of stress from moving the Bosnian Pine, coinciding with the period of meristem activity proved irresistible and this is the probable cause of intense drop-out at this species, rather than drought. Mountain pine as hydrophilic, light-demanding and fast growing species appears most sensitive to drought of the studied species.

Acknowledgements

This work was funded by project № 883/2012LTU-NIS by Bulgarian-Swiss Research Programme 2011 –2016

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Received: 12.11.2013
Accepted: 30.05.2014