საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 175, №3, 2007
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 175, no. 3, 2007

Plant Physiology

Influence of Temperature on Morphological Indices of Soybean and Pea Seedlings

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ABSTRACT. Changes in morphology of soybean (*Glycine hispida* (Moench) Max) and pea (*Pisum sativum* L.) seedlings under the influence of high and damaging temperatures of air (40°C for 1h, 2h, 3h, and 45°C for 1h and 2h respectively) have been evaluated. Heating at 40°C for 1-2h was found to stimulate the growth of seedlings, while exposure to the same temperature for 3h, or at 45°C for 1h caused an abating of the process. Prolonged (2h) exposure to 45°C resulted in the death of soybean seedlings. Pea seedlings appeared to be more resistant to increased temperature (45°C for 2h), but changes in root morphology – necrosis of the main root apex and retardation of growth and lateral root renovation – were noted. Among the soybean organs cotyledons proved the most resistant to overheating. Exposure to temperature led to a regular decrease of water content in seedlings, associated with the temperature level and duration of treatment. Increased temperature (45°C) for 1-2h caused the water content to diminish to about 50%. This served as the cause of growth inhibition. *© 2007 Bull. Georg. Natl. Acad. Sci.*

Key words: *temperature, linear growth, water content, seedlings, soybean, pea.*

Plant's reaction to increased temperature depends on the extent and duration of the exposure to stress-factor. A number of investigations are dedicated to the study of the effect of overheating on the metabolism and productivity of plants [1-3].

The temperature range between 10°C to 25°C is regarded to be optimal for most plants, and 35°C is the upper level of temperature for plant metabolism. An increase of the air temperature to 40°-45°C leads to damage of the photosynthetic apparatus and finally to the plant's death [4]. Therefore, it is known that high temperature stimulates the synthesis of low molecular proteins called "heat shock proteins" [5, 6].

Data on the stimulative effect of increased temperature on growth and application of heat shock as a stimulator of plant tolerance to other stress factors are also presented in the literature [7].

Mainly full-grown individuals are used in studying the effect of stressors on plant, though in natural conditions seedlings are more sensitive to temperature.

Seeds of legumes – soybean (*Glycine hispida* (Moench) Max.) and pea (*Pisum sativum* L.) were previously soaked in water and placed for germination on a wet filter paper at 25°-27°C in darkness for two days. After germination the seedlings were exposed to white illumination for 24h at 50cm distance from the light source. 3 day old seedlings were exposed to increased temperatures of different duration (40°C for 1, 2, and 3h, and 45°C for 1 and 2h). 4 days after treatment morphological observation of seedlings was carried out. Also dry matter and water content of separate organs of seedlings were determined.

Experiments were conducted twice. Each variant consisted of 3-4 biological replications with 10 seedlings. The experiments were analogous to those conducted by T. A. Borisova on water-melon seedlings [7]. Statistical analysis of the data was carried out following the computer program MS-Excel. The diagrams demonstrate the water content of separate organs of soybean and pea in percentage. In the case of morphometric indi-

Table

Influence of different temperatures on growth of 7-day seedlings of soybean and pea

Plant	Seedling's organ	Index	Control	40°C for 1h	40°C for 2h	40°C for 3h	45°C for 1h	45°C for 2h
Soybean	Main root	Length, mm Biomass, mg	43.75±4.23 106±9.2	124±10.5 419±15.3	144±14.1 219±13.6	81.75±4.3 169±10.4	37.5±3.67 139±9.6	Dies
	Lateral root	Maximal length, mm	48.25±29.4	48.75±4.31	50.77±3.06	49.77±5.0	35.62±2.17	Dies
	Hypocotyls	Length, mm Biomass, mg	91.75±6.73 273±8.1	106.33±7.18 282±9.6	99.1±8.32 297±6.8	85.66±7.85 228±4.9	51.12±4.34 159±7.6	Dies
	Cotyledons	Length, mm Width, mm Biomass, mg	17.33±1.14 9.35±0.94 759±15.6	19.05±1.04 10.33±0.74 433±11.3	17.95±1.24 10±0.86 416±8.8	17.55±0.69 9.6±0.59 350±10.6	15.22±0.35 8.55±0.72 308±9.9	Dies
Pea	Main root	Length, mm Biomass, mg	42.37±4.6 98±8.6	90.3±8.37 230±10.9	75.8±7.05 198±8.6	61.0±6.0 196±6.3	41.25±3.89 81±6.9	30.18±3.07 51±4.3
	Lateral root	Maximal length, mm	21.88±2.88	37.8±3.56	26.8±2.74	20.8±2.36	16.16±1.5	9.0±1.0
	Hypocotyls	Length, mm Biomass, mg	10.1±0.38 30±3.2	12.1±1.34 59±4.4	13.25±1.8 40±3.6	8.81±1.54 23±1.5	6.44±1.0 20±1.5	5.0±0.75 20±2.0
	Epicotyls	Length, mm Biomass, mg	20.62±2.03 60±6.4	47.3±4.56 150±8.8	37.7±3.63 110±7.3	27.0±2.26 74±4.0	25.8±2.94 70±5.1	14.8±1.3 43±39

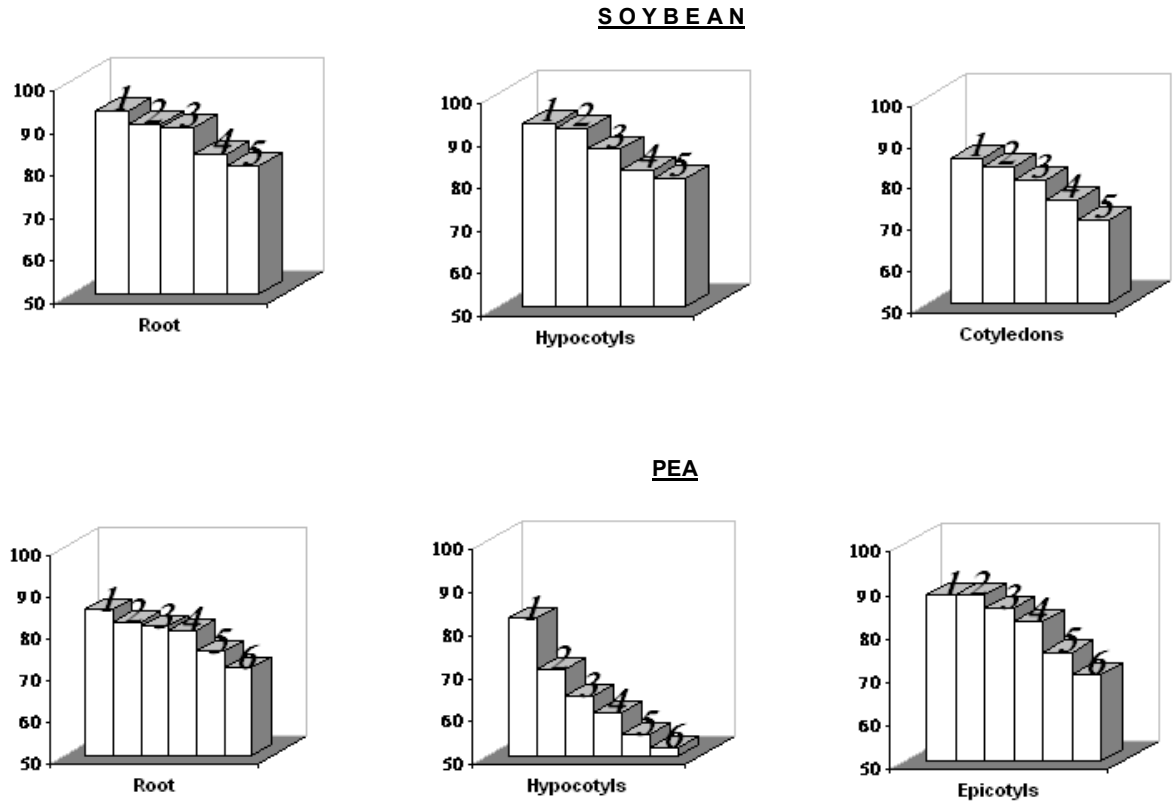

Fig. Influence of temperature on water content in organs of soybean and pea seedlings (%) 1) Control, 2) 40°C for 1h, 3) 40°C for 2h, 4) 40°C for 3h, 5) 45°C for 1h, 6) 45°C for 2h

ces the Tables contain mean arithmetical values and their standard deviations.

Experiments with short-term effect of high temperature showed that the growth reaction of seedlings differed. Exposure of 3-day seedlings of soybean and pea to 40°C for 1-2h stimulated the growth of all organs of the plants. The reaction to temperature stress depended on the duration of exposure. 3h exposure to 40°C and 1h to 45°C caused retardation of seedlings' growth (Table).

Soybean seedlings appeared to be more sensitive to increased temperatures: 2h exposure of 3-day seedlings to 45°C caused the death of most individuals on the 7th day. Necrosis of the main root apex and inhibition of the lateral roots growth, as well as damage of the cotyledons were noticed.

Visual observation first of all showed clearly the damage of the main root and its diminished growth. Cotyledons of the soybean seemed to be more resistant to overheating. This may be accounted for by the physiological peculiarities of cotyledons, determined by their functions: protection of the first leaves and provision of nutrients and energy till their autotrophic transformation [7].

In pea seedlings exposure to 40°C revealed its positive effect on the growth of all organs. Increasing the duration and level of temperature impact to 45°C for 2h caused regular diminishing of the growth intensity of the organs, but seedlings' resistance to stress turned out to be higher, compared with soybean. According to our data, the lethal temperature for soybean was 45°C at 2h exposure, while pea seedlings were more stable, although changes in root morphology, necrosis of the main root apex and inhibition of the lateral root growth were observed (Fig.).

Maintaining the stable level of water content is important for plant adaptation to unfavorable environmental conditions. Comparison of the water content of soybean and pea showed that pea seedlings contained less water than soybean did. Increasing the temperature and duration of the exposure led to the diminishing of water content. 45°C temperature for1-2h caused a reduction of the water content of seedlings by 50% and more in some organs (Fig.). This may be explained by the intensification of transpiration, connected with increasing temperature, causing a disbalance between water uptake by roots and its evaporation by hypocotyls in soybean, or epicotyls in pea, resulting in the growth inhibition of the experimental plants.

მცენარეთა ფიზიოლოგია

ტემპერატურის გავლენა სოიისა და ბარდის აღმონაცენების მორფოლოგიურ მახასიათებლებზე

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შესწავლილია ჰაერის მომატებული ტემპერატურის (40°C 1, 2 და 3 სთ-ის განმავლობაში, 45°C 1 და 2სთ-ის განმავლობაში) გავლენა სოიისა (*Glycine hispida* (Moench) Max) და ბარდის (*Pisum sativum* L.) აღმონაცენების მორფოფიზიოლოგიურ მახასიათებლებზე. მომატებული (40°C) ტემპერატურის 1-2 საათით ზემოქმედება იწვევდა აღმონაცენების ორგანოთა ზრდის სტიმულაციას, ხოლო მაღალი ტემპერატურების ზემოქმედებას (3 საათით 40°C, ან 1 საათით 45°C) თან ახლდა სოიის აღმონაცენების დაღუპვა. ბარდის აღმონაცენები უფრო გამძლე აღმოჩნდა მაღალი (45°C 2სთ-ით) ტემპერატურისადმი, თუმცა აღინიშნებოდა ცვლილებები ფესვის მორფოლოგიაში: მთავარი ფესვის წვერის ნეკროზი, გვერდითი ფესვების ზრდისა და აღდგენის შეფერხება. სოიის აღმონაცენის ორგანოებს შორის ლებნები ყველაზე გამძლე აღმოჩნდა ტემპერატურული შოკისადმი. ტემპერატურის ზემოქმედებამ შესწავლილ მცენარეთა აღმონაცენებში გამოიწვია

ტენის შემცველობის კანონზომიერი შემცირება, რაც ტემპერატურის სიდიდისა და ზემოქმედების ხანგრძლივობის მატებასთან იყო დაკავშირებული. ტემპერატურის მომატება 45°C-მდე 1-2 საათით თითქმის 50%-ით, და ზოგ ორგანოში მეტადაც, ამცირებდა წყლის შემცველობას აღმონაცენებში, რამაც თავის მხრივ ზრდის ინჰიბირება გამოიწვია.

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Received December, 2006