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Ecological-biological Aspects of *Stipa krylovii* Roshev Adaptation at the Initial Stages of Ontogenesis

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Xerophytic cereal *Stipa krylovii Roshev* is interesting as a relic with extensive capabilities to adapt to severe climatic conditions of Eastern Zabaikal'ye, which allows it to occupy a vast areal. The species under study is characterized by distinctive ecological-biological peculiarities, which are underpinned by not only distribution, but historical establishment of the species.

The primary goal of the research was to study ecological-biological peculiarities of adaptation of wild cereal *Stipa krylovii* to the habitat in Eastern Zabaikal'ye.

According to the observations, *Stipa krylovii* is characterized by late development rate coinciding with the period of optimal heat and moisture availability. Seed embryos have a well-developed scutellum, distinct structures and well differentiated embryo axis. The studies identified no lateral or secondary roots in the cereal. In nature, seeds of *S. krylovii* are characterized by profound organic peace period, which persists in the course of sprouting under optimal conditions. Peace period of *S. krylovii* caryopses is likely to be due to the presence of sprouting inhibitors and is overcome in moist autumn period. Seed viability was determined under various soil moisture parameters up to its complete water capacity; the impact of moisture content on seed sprouting rate was studied. The results of the tests on caryopses sprouting with various moisture content demonstrated that at minimum moisture content (10%) *S. krylovii* forms epidermal hairs on coleorhiza; 30% of soil water content is enough for growth activation, viability and sprouting rate of this cereal, which is due to its xerophytic nature. This morphological peculiarity is likely to ensure in nature sprouting of these species in early spring, when soil contain minimum water. Intensity of the initial growth was determined by a number of parameters: rate of change in linear growth of trunk and root parts of the embryo, growth of dry substance of plantlets and roots (4-th and 6-th days of sprouting).

Thus, characteristic morphological peculiarities in cereal structure play a certain role in adapting sprouting seeds to moisture deficit; so embryos of the species may be supposed to have their morphological mechanisms of regulating moisture absorption. Study of individual embryo parts demonstrates potential ecological-biological abilities of embryos to sprout with lack and excess of moisture.

Key words: adaptation, moisture, morphological structures, needle-grass.

Natural climatic conditions of Eastern Zabaikal'ye are characterized by lack of heat and moisture, as well as by short vegetation period, which restricts plant growth and development. Under sever conditions of the region phylogenetic development of local flora followed the route of developing diverse mechanisms, which ensure plant growth under extreme conditions. Mechanisms of this adaptation are not sufficiently studied. Numerous publications, including those issued abroad, are dedicated to cultivated plants, while wild species are poorly covered, wild relic species of Eastern Zabaikal'ye being least investigated. With this in view, the problem of studying ecological-biological mechanisms of adaptation of wild cereals of Eastern Zabaikal'ye is critical, and the solution of this problem will make a significant contribution to the enhancement of knowledge of plant adaptation to habitat.

The primary aim of the study was to investigate ecological-biological peculiarities of wild cereal *Stipa krylovii* adaptation to Eastern Zabaikal'ye habitat.

MATERIALS AND METHODS

Xerophytic cereal Stipa krylovii Roshev is interesting as a relic with extensive capabilities to adapt to severe climatic conditions of Eastern Zabaikal'ye, which allows it to occupy a vast areal. Besides, the species under study is characterized by distinctive ecological-biological peculiarities, which are underpinned by not only distribution, but historical establishment of the species.

Cleaned seeds were kept in paper bags in laboratory conditions, or were subjected to stratification in water at 1 – 4^{0}C. To determine caryopses viability GOST 12038 – 84 was used; in keeping with its standards, seed is considered to be a geminated seed, if its root equals half of the seed length. Results of daily counting of germinated seeds provided data on seed germination rate. This parameter was evaluated by H. Peaper' formula in F.I. Reimers', I.E. Illi's modification (1978).

Energy of seed germination (*E*), or seedling vigor was determined by the number of seeds germinated over a specific number of days identified for each species, in per cent to the number of sown seeds.

Morphology of embryo formation was studied on the basis of microscopic analysis method. Anatomic peculiarities of cereal embryos' maturity were determined on temporary preparations as per the methods described in (Furst, 1979). Cereal embryo structures were measured by microscopy with an ocular micrometer, scale interval was calculated in micrometers based on the standard scale of an object micrometer.

Microphotos of dorsoventral sections were obtained with «Olimpus» camera and «Mekos» software. Morphology was studied by histological method: caryopses were germinated in a thermostat at 20^0 – 24^0 in Petri dishes on filtered paper, as well as on sand with various moisture level - 10%, 30%, 50%, 70% of total water capacity during 3 days. Measurements were conducted in 0, 24, 48, 72 hours after the start of germination. Ocular micrometer was used to measure on temporary preparations length and width of coleoptile, first leaf, scutellum, epiblast, root, coleorhiza under Biolam microscope.

RESULTS

Stipa krylovii begins to grow about second week of May, bush formation starts in late May. Blossoming begins about third week of July and ends by mid- August. Seeds are formed by late August – early September. According to our observations, *Stipa krylovii* is characterized by late development rate coinciding with the time period with optimal heat and moister levels.

Favorable weather conditions during seed formation period foster formation of robust caryopses embryos. Cereal embryo is known to have dorsoventral structure (Fig. 1) (Larina, 2004, Chistyakova, 2009, 2011, 2012). Using ocular-micrometer we measured on dorsoventral median sections of embryos linear parameters of coleoptile, first embryo leaf, epiblast, first embryo root, coleorhiza, щитка and total length of embryonic axis (Table 1). According to our findings, seed embryos have a well developed plate, distinct structures and a differentiated embryo axis. Our study did not confirm presence of lateral or auxiliary embryo roots in the cereal.

S. krylovii seeds in nature go through a profound organic peace period, which is not eliminated during sprouting in optimal conditions. This is confirmed by low laboratory viability (Table 2). Seeds of *S. krylovii*, like those of most wild cereals have a high viability and biological persistence. Their low viability presumes that peace period was not terminated. Cutting the top of caryopses or pricking of seeds in all the tests accelerated sprouting and increased viability by 11 – 20%. This indirectly proves that peace of *S. krylovii* caryopses is likely to be due to the presence of sprouting inhibitors, and is overcome in humid autumn period.

In nature seeds are subjected to various conditions, which form a complex of numerous tightly interrelated climatic and soil factors. They may be determined by geographical diversity of territories, seasonal climate fluctuations, as well as microclimatic and soil peculiarities.

Unfavorable moisture conditions characterizing climate of Eastern Zabaikal'ye produce a major impact of sprouting and further seedling growth. With this in view, it is crucial to determine the ability of seeds of the cereals studied to sprout with various moisture levels in soil. These distinctions may be found by such parameters as viability, energy (E) and sprouting rate (V) of seeds.

We used for the tests the caryopses, peace period of which was partially or fully eliminated. Laboratory viability of seeds was determined as percentage of seeds sprouted under optimal conditions. Seeds with the root length equaling half of seed length are conventionally considered to be sprouted. However, laboratory viability is largely identified with the ability of seeds to sprout.

According to Table 3, the cereal seeds sprout with various soil moisture. Enhanced seed viability is observed in *S. krylovii* at 30% soil moisture of its full water capacity. At 10% moisture *S. krylovii* demonstrates decrease of seed viability, excessive moisture content in soil - 70% - suppresses seedlings growth. Sprouting energy was determined as the number of seeds sprouted during a certain period (days) for each plant species, in per cent to those sown. The following test series were dedicated to the impact of moisture level on sprouting rate. Sprouting rate is interpreted in different ways by different authors: as a proportion of the share of sprouted seeds to the sprouting period or as an average sprouting time of one seed. Sprouting rate is determined by the average number of days required for sprouting of one seed. Evaluation of the role of each morphological structure in sprouting manifested changes in the size of coleorhiza, coleoptile, root and epiblast at different moisture of substrate (Larina, 2004, Chistyakova, 2009, 2012, 2014, 2015). Results of the tests on caryopses sprouting in different moisture level conditions showed that in *S. krylovii* with minimal moisture content (10%) coleorhiza begins to develop epidermal hairs.

Figure 1. Dorsoventral embryo section of Stipakrylovii: 1 – scutellum, 2 – coleoptile; 3 – embryo leaf; 4 – embryo root, 5 - coleorhiza, 6 – epiblast.

Table 1. Parameters of morphological structures of mature seed embryos of xerophytic cereal *Stipa krylovii*, mkm

Embryo anatomic part	***Stipa krylovii***
Embryonic axis length	1243,05±1,4
Coleoptile width	407,52±1,6
Coleoptile length	673,92±1,3
First leaf width	223,92±1,4
Embryonic root width	309,13±1,8
Embryonic root length	366,54±1,5
Epiblast length	367,04±1,5
Epiblast width	105,70±1,4
Coleorhiza thickness	141,55±1,6
Scutellum length	1173,23±1,6
Scutellum width	243,23±1,5

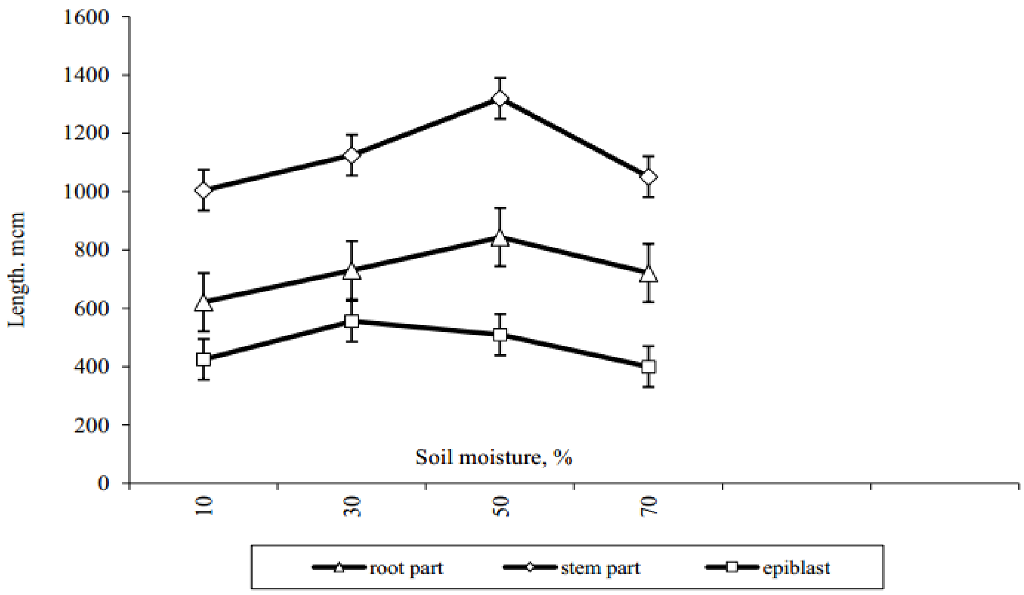

Figure 2. Impact of soil moisture conditions on longitudinal growth of stem and root parts of seed embryos (48 hours).

Table 2. Laboratory viability of *S. krylovii* mature seeds, %

Seed viability, days						
3 days after collection	30	60	90	120	150	180
22,8	26,4	27,1	26,0	24,2	25,2	25,0

Table 3. Parameters of potential sprouting ability of *S. krylovii* seeds with various soil moisture (%)

Soil moisture, %	Viability, %	Sprouting E, %	Sprouting V, days
10	52	50,1	3,9
30	58	55,9	3,5
50	66	63,5	3,3
70	42	37,4	3,6
100	-	-	-
Total flooding	-	-	-

Coleorhiza hairs are identical to root hairs (Larina, 2004, Chistyakova, 2009). Maximal development of *S. krylovii* root hair net is achieved at 30%. At soil moisture ranging from 50% to 70% y *S. krylovii* the number of hairs and their length decreases. Moisture content of 10% and 70% entails oppression, so at 70% of soil moisture hair roots development is virtually not observed.

The test results showed that 30% soils moisture of its full water capacity suffice to activate growth, viability and sprouting rate of this cereal, which is due to its xerophytic nature. This is also fostered by the development of root hairs mentioned above. This morphological peculiarity is likely to ensure sprouting of seeds of this species in nature in early spring, when soil contains least moisture. The most intense growth of *S. krylovii embryonic* morphological structures (coleoptile and roots) was observed at 50% soil moisture of its full water content (Fig. 2).

Intensity of the initial growth is determined by a complex of parameters, like rate of change in linear growth of root and stem embryonic parts and increment of dry matter in seedlings and roots. Seedlings' ability to surface largely depends on the activity of their growth during heterotrophic nutrition period. With this in view, we determined length of stem and root parts of seedlings of the investigated wild cereals on the 4-th and 6-th days of sprouting.

The longest part of needle-grass embryos is on the tissue of basal part of the axis, that is why sprouting embryo breaks the seed shell first of all in this area. This also confirms physiological role played by coleorhiza in the course of seed shell breaking during embryo sprouting (Illi, 1989, Larina, Chistyakova, 2015).

Our experiments demonstrated that during sprouting cells of this morphological organ actively extend and by 48 hours reach their maximal size. Tests on seed sprouting with different substrate moisture level showed that *S. krylovii* has maximum epiblast growth at 30% of soil moisture level (Fig. 2). Within moisture range of 30 to 70% of its full water capacity epiblast growth rate does not depend on water content in the environment.

S. krylovii has the highest potential adaptation abilities. Active growth of embryonic structures is apparently due to mobilization of storage proteins and start-up of enzyme systems during soil moisture deficit. Coleoptile growth is provoked by the decrease of heterotrophic period and transition of the seedling to heterotrophic nutrition under unfavorable moisture conditions in nature.

Therefore, characteristic morphological peculiarities in cereal structure play a specific role in the process of adaptation of sprouting seeds to moisture deficit and the species' embryos may be supposed to have their morphological mechanisms of moisture absorption. Study of individual embryo parts demonstrates potential ecological-biological abilities of embryos to sprout in conditions characterized by lack and excess of moisture.

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