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STATE SCIENTIFIC INSTITUTION ALL-RUSSIAN SCIENTIFIC-RESEARCH INSTITUTE OF GRAIN CROPS AFTER I.G. KALINENKO (SPI ARRIGC AFTER I.G. KALINENKO)
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Drought resistance in winter wheat.

Drought resistance is the ability of a plant to change metabolic processes as little as possible during conditions of insufficient water supply. The adaptiveness of a plant determines the structural degree of the fibers. The physiological functions of a plant are connected closely with its morphology and anatomy. The xerophytic structure of winter wheat promotes its resistance to drought during all vegetative periods. The harder and longer the drought, the greater the influence of xerophytic characters on yield elements.

The xerophytic nature of a plant can be assessed using stomata number per leaf area. To determine this value in wheat, we measured stomata/leaf are in flag leaves, in the middle of the leaf, and along the both sides of a central vein. The greater the number of stomata, the more xerophytic the cultivar. Other criteria for drought resistance are a water deficit determination, such as the lack of water present in a plant during a drought and residual water deficit, which is the amount of water present in the early morning. Our work revealed a correlation between residual water deficit signs with a level of variety drought resistance (r = 0.91). Field observations were made during the drought conditions in 2003, 2005, 2007, and 2009.

Xerophytic cultivars posses high levels of complex plant stability index (distinguished at the primary developmental stages). The greatest number of stomata/leaf area, i.e., more xerophytic, and water and temperature stress resistance were the cultivars Don 93, Ermak, and Zarnitsa. Winter wheat cultivars have a high (r = 0.99) correlation dependence of xerophytes value and complex resistance index. Xerophytic structure promotes the economic and efficient consumption of water by the leaves and is expressed more in genotypes resistant to drought. These conclusions were confirmed in the laboratory and by evaluating the drought resistance of winter wheat in a field experiment.

In the field, increased water content in the leaves increases drought resistance if not accompanied by a decrease in ventilation. We took into consideration the degree of leaf ventilation, i.e., we determined a number of open stomata per leaf square. Cultivars with an increase in xerophytic characteristics possess a high water holding ability. For example, Don 105 has the lowest residual water deficit at flowering (10%) and has the greatest number of stomata/leaf are ($27/mm^2$). The cultivars Deviz, Don 95, and Don Kolos, which had the greatest moisture deficits of 27, 30, and 36%, respectively, possessed the smallest number of stomata/leaf area, 13, 12, and $8/mm^2$, respectively. The correlation between xerophytic value and the residual deficit is r = 0.42 (medium).

Drought-resistant cultivars can lose water without harm and need not close stomata significantly longer, even in periods of a harvest drought, positively influencing assimilation speed, increasing CO_2, and strengthening the photosynthesis process; these processes increase stomata conductivity. Drought-resistant cultivars have a better developed system for conserving water in the plant fibers, the greatest number of stomata/leaf area, and a more developed water conducting system in the stem and leaves.

Lodging in winter durum wheat.

E.V. Ionova, N.N. Anisimova, V.L. Gaze, and N.E. Samofalova.

Lodging significantly decreases the productivity of grain crops. Early and intense lodging can cause a productivity loss of 60%. All grain crops are subject to lodging, including such stable plants as sorghum and maize. In the field, lodging is preceded by a gradually increase of unfavorable changes in anatomic-morphologic and physiologic processes. Comparing the morphologic and anatomic characteristics during lodging reveals plant reaction during sprouting.

The level of lodging was determined after assessing the density of supporting fibers in durum winter wheat cutivars resistant and susceptible to lodging. Cross sections of the lower part of the first two main stem internodes at milkly ripe phase of grain were stained with a 1% safranin solution. Using an ocular-micrometer, the hypoderm thickness was measured the number of cells calculated. The hypoderm consists of a number of vascular-fibro bundles in hypodermis and parenchyma.

The thickness of the mechanical fibers in cultivars resistant to lodging are larger than those of susceptible cultivars. The thickness in resistant cultivars at the first internode is 8.7 mkm and 8.6 mkm at the second, compared to 7.4 mkm and 7.5 mkm, respectively, for susceptible cultivars. Cultivars resistant to lodging have 4.1 and 4.2 rows of mechanical internode fibers and susceptible cultivars have only 3.5 and 3.6 rows. The vascular bundles are situated in the stem walls. Bundles coming through the hypoderm are very tiny, located at great distances from each other. In the parenchyma next to the large vascular bundles form an inner ring in the stem. The bundle walls consist of mechanical fibers, comprised of thin, stretched fibers that strengthen the stalk. In resistant cultivars, 18.8 conducting bundles are in the mechanical fibers at the first internode and 20.0 at the second internode. In lodging-susceptible cultivars, there are 13.0 mechanical fiber conducting bundles at the first internode and 13.8 at the second internode. Stable cultivars have 29.1 conducting bundles in the parenchyma at the first internode and 30.6 at the second internode, whereas susceptible cultivars have 26.1 and 26.7 at the first and second internodes, respectively.

The diameter of the internode of resistant cultivars is 34 mkm or 18% more than that in susceptible lines. Significant differences were noted in the diameter of the first and the second internodes among the cultivars. Resistant samples have a first internode diameter of 39.8 mkm greater (390.4 mkm) compared with susceptible cultivars (350.6 mkm). The difference of the size of the second internode is a little greater among samples of the different stability groups, 418.9 mkm (resistant samples) and 377.0 mkm (susceptible samples).

Our experiments established that the growing conditions greatly influence the dimensions of the stalk fibers and their correlation. In dry conditions, the epidermal cells are larger, the walls thicker, parenchyma greatly diminishes although the dimensions of individual cells do not change much, the number of chlorophyll-carrying cells decreases, and the dimensions and number of vascular bundles change. The basic features that determine stability are those of the inner stem structure, number of vascular fiber bundles, thickness of the mechanical fabric ring, and the degree of sclerefication of all cell walls.

Lodging occurs more frequently when soil is extra moist. Stems in the lower part of the plant stretch, cell walls become thinner, mechanical fabrics develop weaker, and stem firmness decreases. The principal way to fight lodging is selection and introduction of nonlodging cultivars in agricultural production.

Root system development of winter wheat in drought conditions.

E.V. Ionova, N.N. Anisimova, V.L. Gaze, and T.A. Gritchanikova.

All structures and plant organs, including the root system, help form drought and heat resistance properties. The development of the primary root system of different winter wheat cultivars was evaluated in a growth chamber after 14 days with a 16-hour daylength (18,000 Lux), a day temperature of 19–20°C, and a night temperature of 11–12°C. The experiments was replicated three times. Experimental variants were optimal soil moisture, 70% PV (control), and 30% PV (soil drought). To determine the increase in roots, we germinated seed in filter paper rolls on a full nutrient mixture of Knopp's Solution under different soil temperature regimes (8-12°C, 14-16°C, and 28-32°C). The length of the main germ root was measured after 7 and 14 days; the difference is the increase of root dimension.

At 30% PV (experimental drought), the length of the longest root varied from 17.4 to 26.5 cm and from 22.3 to 30.5 cm at optimal moisture (control). The maximum root length under insufficient water conditions was in the cultivars Ermak (26.5 cm), Donskoy Surpriz (25.3 cm), and Don 93 (24.9 cm).

The germ root varied between 0.56 and 0.86 in drought and between 0.66 and 1.12 at optimal water provision. The largest values ere noted in cultivars Ermak (0.86), Deviz (0.81), and Don 93 (0.78). In the control treatment, Donskoy Surpriz (1.12), Don 93 (1.10), Ermak (1.0), and Donskoy Prostor (1.0) had the largest values. At 30% PV, the maximum dry root mass was in Ermak (10.0 mg), Donskoy Surpriz (9.2 mg), and Don 93 (8.6 mg). The largest ratio of absolute dry root mass to the greatest root length was in Donskoy Majak (0.39 mg/sm) and Ermak (0.38 mg/sm). These results indicated the best cultivars for all parameters of primary root system development were Ermak, Donskoy Surpriz, and Don 93.

Besides moisture, air and soil temperature greatly influence root system formation in wheat (Table 1). A maximum root increase (105.5–148.3%) was noted at 14-16°C. The greatest increase at this temperature was in Ermak, Dar Zernograda, Don 93, and Deviz. At 8–12°C, root increase was not more than 94.4–133.4% with the greatest increases in Ermak, Dar Zernograda, and Don 93. The increase in roots at 28-32°C was 87.3–120.1%. The minimum reduction in the roots under the influence of high temperature was noted in Ermak (13.3 and 28.2%) and Dar Zernograda (3.1 and 12.9%). The lowest increase at all experimental temperature regimes were in Donskaya Bezostaya.

Table 1. Increase in roots of winter wheat under different temperature regimes.

Cultivar	Root increase (%) at temperature		
	8–12°C	14–16°C	28–32°C
Dar Zernograda	130.8	140.6	127.7
Donskoy Majak	120.9	130.0	114.3
Ermak	133.4	148.3	120.1
Stanitchnaya	114.7	128.9	108.8
Donskoy Surpriz	115.6	123.0	105.2
Garant	109.9	129.2	109.9
Don 93	129.0	133.4	119.2
Donskaya Bezostaya	94.4	105.5	87.3
Donskoy Prostor	107.8	114.0	99.7
Deviz	121.0	131.1	111.4
Don 95	98.1	107.0	89.9

The evaluation of winter wheat root system development under different soil warming temperature in the laboratory were practically identical to those from field experiments in 2000–09. In the field experiments, root systems growing at 8–12°C soil temperature consisted of big, strong roots. Roots growing at 14-16°C soil temperature are greatly ramified and their dimensions are greater than those of the first regime. At 28–32°C, branching of roots increases, they become thin, and their color changes from white to brown. Roots growing at 40°C become thick, nutrient absorbtion slows, and, as a result, a decrease of root dry mass takes place (30–40%). Thus, winter wheat roots develop better at low soil temperatures. Substantial root systems depend on temperature and moisture. Changes in root activity in the right direction and selecting the best cultivars accordingly help the selection process.

Winter wheat selection in the Don area.

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Winter wheat is one of the most significant food grain crops in Russia. Winter wheat in the Don area in some years supplies up to 70% of the gross yield of grain in the Russian Federation. The area under winter wheat in 2009 in the Rostov region was 2,071.5 ha; 53,02% were winter wheat cultivars selected by the SPI ARRIGC. In the Rostov region, which is traditionally a strong and valuable wheat production zone according to its climatic conditions, the grain quality has become noticeably worse and dependent upon the natural climatic conditions, which have become more arable during the past years. The yearly amount of high-quality grain of strong and valuable wheat were 2,640 x 10^3 ton in 1990, 2.9 x 10^3 ton in 2000, 30.3 x 10^3 ton in 2001, and 3,526.2 x 10^3 ton in 2009. To decrease dependence, it is necessary to select agricultural crops according to the zone more favorable for their cultivation and choose cultivars that have a stable, high-quality grain production.

The State Register recommended 47 winter wheat cultivars, including 24 (51%) selected by the SPI ARRIGC for the Rostov region for 2010. Thirty-nine of the cultivars (83%) are strong and valuable wheats according to their quality, including 23 cultivars (48.9%) selected by the SPI ARRIGC. The most important priorities for wheat selection in the Don area, together with an increase in potential productivity and ecologic stability are greater protein, gluten, baking, and macaroni properties. As a result of purposeful selection, the high-quality, drought resistant, highly productive winter wheats with a potential productivity of 8–10 tons/ha were Zernogradka-10, Zernogradka-11, Rostovtchanka-3, Konkurent, Tanais, and Rostovtchanka-5 for predecessors of black pairs and Don 93, Ermak, Stanitchnaya, Don 105, and Don Surpriz for nonpair predecessors.

Lately, an interes durum winter wheat has grown. The greatest achievement of domestic selection for macaroni/cereal usage were the cultivars Don Jantar, Aksinit, Gelios, and Kurant, being highly productive with a potential productivity of 7.0–9.0 t/ha, drought resistant, and winterhardy. These cultivars may help solve the deficit of durum grain in the North-Caucasus region.

Cultivars selected by the SPI ARRIGC are able to realize a high level of productivity and quality only when recommended cultivation technology is followed, such as use of fertilizer; feeding during the vegetative period; protection from diseases and pests including insects and the harmful tortoise; and timely harvest. Using quality winter wheat cultivars and the best cultivation technologies will allow agricultural producers to increase the production of high-quality grain.

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Necrotic genotypes in winter bread wheat in the Russian Federation.

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The hybrid necrosis genes (*Ne1* and *Ne2*) are valuable tools for comparing wheat species and their groups within the genus and evaluating anthropogenic influence on genetic erosion. Hybrid necrosis genes interact by a complementary mechanism (Kostyuchenko 1936). Both genes are located in the B genome. The *Ne1* gene is located on chromosome 5BL and the *Ne2* gene on chromosome 2BS. Allele series for each gene have been demonstrated. The alleles of the *Ne1* gene are *w*, *m*, and *s*, and the alleles of the *Ne2* gene are *w*, *wm*, *m*, *ms*, and *s* (Hermsen 1960, 1963; Chu et al. 2006). Knowledge of the necrotic genotype is also important for selection and evaluation of the original material during breeding of wheat and triticale. About ten new cultivars of common wheat recommended for commercial use are registered in the Russian Federation. Although the data on yield, vegetation period, and resistance to main phytopathogens are available, information concerning genes, and hybrid necrosis genes in particular, is missing. Our work analyzes the distribution of hybrid necrosis genes among wheats of Russia and other countries (Pukhalskiy 1996; Pukhalskiy et al. 2000, 2003).

Here we present our data on necrotic genotypes in 53 cultivars of winter bread wheat (Table 1, pp. 221-222). Most were produced after 2000. The following cultivars were used as testers: Felix (*ne1ne1Ne2Ne2*), Co725082 (*Ne1sNe1sne2ne2*), Mironovskaya 808 (*ne1ne1Ne2msNe2ms*), Nemchinovskaya 52 (*ne1ne1Ne2msNe2ms*), and Berthold (*ne1ne1Ne2mNe2m*). Crossings were conducted in the field by a twel-procedure. Hybrids were grown in the field. Necrotic symptoms were evaluated at different ontogeny stages. Pedigree analysis was conducted with an analytical GRIS system.