Breeding of soft spring wheat in a changing climate

V.V. Novokhatin

Tyumen Scientific Center SB RAS, Tyumen, Russia

DOI 10.18699/ICG-PlantGen2019-06

* e-mail: natalya_sharapov@bk.ru

Abstract: When creating the initial breeding material, the use of the family tree of parental varieties allows you to establish the geography of their origin and determine the dynamics of lim-factors of the environment at these geographic points. Hence a possibility to transfer endurance to hybrids to lim-factors of the environment of this zone. The hereditary increase in drought tolerance is due to the ecological-genetic organization of the quantitative traits of the family-defined genetic and physiological systems (GFS) that determine the crop, of which the main ones are: attraction, microdistribution, attracted plastic substances, adaptability, horizontal immunity, tolerance to thickening. Evaluation of the breeding material for these GFS allowed us to distinguish the early maturing line Lutescens 506-11, with their optimal manifestations and pronounced adaptability to the agroclimatic conditions of the Trans-Urals, which became the Grenada variety.
Key words: variety; family tree; lim-factor; environments; genetic-physiological system.

1. Introduction

Selection of soft spring wheat, in conditions with a pronounced aridity of the first half of the growing season, should be carried out taking into account the creation of the source material based on the expanded genealogical tree of the parental forms. This allows you to identify lim-factors at the geographic points of their origin and to combine in the created hybrids resistance to their negative manifestation. Evaluation of the created breeding material for seven genetic- physiological systems allows objectively selecting the genotypes that are most adaptive to local conditions, high-yielding, with a complex of economically valuable traits and properties.

2. Material and methods

Experimental work was carried out on the experimental field of the Research Institute of Agriculture of the Northern Zauralye (a branch of the Tyumen Scientific Center of the Siberian Branch of the Russian Academy of Sciences), in the conditions of the northern forest-steppe zone, on dark gray soil, fertilized with N30P45K30 kg/ha. As the source material, the material of the VIR collection was studied in the amount of 1200 samples of various ecological and geographical origin (Guidelines …, 1985). Hybridization was carried out using the TV-method. F1, F2 and B1-B4 hybrids and breeding material were studied by the selection method (The program …, 2011). The selection of elite plants is after a series of stabilizing transfers of hybrid populations against the background of typical dynamics of lim-factors of the environment. Competitive and environmental testing was carried out according to the method of GSI (Methods …, 1989).

3. Research results

The genealogical tree of parental components allows us to establish the geography of their origin and to reveal the dynamics of lim-factors of the environment at various geographic points. The genealogical tree shows kinship in the dynamics of selection, which is "... evolution directed by the will of man" (Vavilov, 1935). The pedigree of the created varieties allows one to theoretically substantiate the selection of pairs for crossing (Ushiyama et al., 2009; Witcombe, Virk, 2009; Novokhatin, 2016), to conduct a directed formative process and the selection of the necessary ecotypes (Novokhatin, 2016). So the family tree of the mid-season, intensive variety Icarus (var. pyrotrix) consists of 59 varieties, which cover eight secondary centers of the evolutionary development of culture. In the pedigree of the newly registered variety Grenada, the family tree includes 69 varieties of various genetic and ecological-geographical origin (Drahavtsev et al., 1984). In the conditions of climate warming, in the Northern Trans-Urals during the past forty years, the average air temperature has increased from 1.2 to 2.8 °C, and over the past 10 years it increased to 3.1 °C. With an increase in positive active temperatures from 1847 to 2138 °C (SCC = 1.31) (Novokhatin, 2015), the question of adapting the selection to dry conditions is urgent. The climate of the region has significant differences from those of the surrounding areas, since it is largely determined by the Scandinavian warm anticyclone and impoverished western cyclones. Analysis of the data of the Tyumen HMS for 103 years shows that in the Northern Trans-Urals there were 46 % of years of droughts of varying degrees, of which 36 were significant, 11 years were dry and 8 were very dry, and 26 years were wet (Novokhatin, 2015). Productivity – as a complex indicator – is determined by the ecological-genetic organization of quantitative traits (Drahavtsev et al., 1984). Under climate warming conditions, a hereditary increase in drought resistance is required, one of the main factors of adaptability (Drahavtsev, 2019), which causes a change in the spectra of the products of the genes determining yield (Drahavtsev et al., 1984). At the same time, drought resistance is determined by 22 components, each of which has a share of additive dispersion in a particular set of varieties. Based on the fact that plants have seven genetic and physiological systems (GFS) determining yield, the attraction of the microdistribution of traced plastic substances, adaptability, horizontal immunity, payment for dry biomass of the lim-factor of soil nutrition, tolerance to thickening and variability of ontogenesis phases (Drahavtsev et al., 2017) should be taken into account in the breeding work. Among them, one of the determining factors is the GFS of adaptability to common lim-factors in the zone: drought resistance, cold resistance, heat resistance, resistance to salinity and acidic soils, to lodging and to germination of grain in the ear. The rate of adaptability depends on the genotype-environment interaction (HCV), which varies with the productivity ranks of varieties. In the Northern Trans-Urals, out of 25 % of the genetic component, in the formation of yields (from 100 % phenotypic variability) about 20 % are caused by genotype-environment interaction (HCV) (Novokhatin, Shelomentseva, 2014), which is an important factor in increasing productivity. Among the 22 components of drought tolerance included in the seven HFS, an important component is the root system that changes in ontogenesis. A large embryo has well-differentiated elements, which makes it possible to select genotypes with 5–6 actively growing germinal roots. At tillering, in rainfed conditions, the primary roots penetrate the soil by 50–70 cm, at earing stage – 130–150 cm and at full ripeness stage – 170–185 cm, and on irrigation – 210–243 cm, the maximum was shown for Kazakhstanskaya 10 cultivar. In dry conditions, the primary root system determines grain yield for early ripening varieties – 77–80 %, middle ripening – 67–69 % and late ripening – 53–56 %. It was found that the morphological index associated with drought tolerance is the magnitude of the removal of the spike (Novokhatin, 2015). It should be borne in mind that spring wheat hybrids obtained with the participation of winter forms have a more developed and deeper penetrating secondary root system. Complex, often changing climatic conditions require the creation of well-adapted, plastic varieties. This is largely solvable when use in the breeding work all seven genetic-physiological systems (GFS) contributing to productivity. Evaluation of breeding lines on the main five GFS allowed identification, among them, of Lutescens 506-11 F5 [F1 (Kazakhstani early maturation × Tulunskaya 12) × Tulunskaya 12], which became the variety Grenada. In 'Grenada', the attraction is well pronounced: the recycling of plastic substances from the stem and leaves into an ear. This provides a full-bodied, well-ribbed ear. The new variety shows resistance to early summer drought due to a well-developed root system and dense cuticular wax coating. The variety is able to develop well and form high quality grain on slightly acidic soils and in cool conditions. The GFS of polygenic immunity (horizontal stability) of 'Grenada' is caused by a strong cuticular wax coating of leaves and stem, a gray-blue color, which prevents germination of fungal spores – septarios, rust, powdery mildew. Dense pubescence of leaves and leaf sheaths limits the accumulation of spores on them, protects them from damage by stealth and leaf-eating pests, and as albedo protects plants from overheating. GFS tolerance to thickening is one of the main criteria for the creation of varieties for intensive farming. A productive cenosis should provide from 510 to 560 productive tillers on 1 m^2. With a grain mass from an ear of 1.1–1.2 (28–30 grains with a grain weight of 0.04 g), the biological yield is from 5.5 to 6.4 t/ha, which is typical of the new variety Grenada. Improving Drought tolerance should be improved with the help of wild species. An example of those is the variety Serebrina, a somatic hybrid of intensive 'Kazakhstanskaya 10' and non-extruded nuclear material of bluegrass meadowgrass, characterized by a combination of drought tolerance and resistance to pathogens and pests. Drought tolerance and adaptability of wheat are enhanced by transgenesis, by introducing amphidiploid genes by inserting foreign DNA into the recipient's genome. Breeding forms with triticale and sphaerococcum wheat were obtained. Newly created varieties should be resistant to lodging and to the pre-harvest germination of grain in the ear. This is possible only when evaluating the breeding material in provocative conditions. Thus, resistance to pre-harvest germination of grain in an ear is estimated by the activity of the α-amylase complex and pre-harvest germination of grain in an ear in provocative laboratory conditions.

4. Conclusions

The use of the genealogical tree of parental forms allows you to identify lim-factors of the environment at geographical points of their origin. This allows to create hybrids resistant to environmens. Evaluation of breeding lines for seven genetic-physiological systems (GFS) allows to select productive genotypes, adaptive to local conditions, with a complex of agronomically valuable traits and properties. The analogue is the early ripe cultivar Grenada, created and registered in 2019, with horizontal resistance to pathogens.

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Conflict of interest. The authors declare no conflict of interest.