The extreme factors influence on the grain quality technological indicators of spring wheat of Siberian selection

N S Kozulina¹,³, L V Fomina and Zh N Shmeleva²

¹FSBSI “Federal research center “Krasnoyarsk scientific center of the Siberian branch of the Russian Academy of Sciences” (FRC KSC SB RAS) KRASNOYARSK SCIENTIFIC-RESEARCH INSTITUTE OF AGRICULTURE – separate subdivision of FRC KSC SB RAS (KrasSRIA FRC KSC SB RAS), 660041 Svobodny, 66, Krasnoyarsk, Russian Federation
²Krasnoyarsk state agrarian university, Mira Avenue, 90, Krasnoyarsk, 660049, Russian Federation
³E-mail: kozulina.n@bk.ru

Abstract. Cultivation of agricultural crops and obtaining stable yields with high technological qualities of grain are often limited by extreme environmental conditions during the plant growing season. Mongolian agriculture is characterized by a high level of dependence on natural conditions, resources, and changes in ecological systems. Sharp temperature fluctuations, high contrast and insufficient precipitation during the growing season create extreme factors for cultivating crops in Mongolia. Spring wheat varieties of Siberian selection are resistant to adverse environmental factors and have good baking qualities. In the framework of the contract between the Krasnoyarsk state agrarian university and HHK “IngetTolgoy” company (Mongolia), the research on studying extreme factors influence on the technological parameters of spring wheat grain of Siberian selection on the land of HHK “IngetTolgoy” company was conducted. The objects of research were wheat varieties of Siberian selection Novosibirskaya – 15, Novosibirskaya – 31, Kantegirskaya – 89 and varieties Selenge and Tsagaan dagliy, cultivated in HHK “IngetTolgoy” company. Recording was performed using generally accepted methods and existing State Standards. Statistical processing of the obtained data was performed by the method of dispersion and correlation analysis. The obtained results allow to conclude that despite the influence of extreme factors on wheat during the entire growing season, the highest biological yield and the best technological qualities of grain were formed by the spring wheat variety of Siberian selection Novosibirskaya – 31.

1. Introduction

Mongolian agriculture has an animal husbandry and agricultural direction. It employs about half of the country’s population, and its products make up the majority of the country’s exports. Due to products from wheat grain, up to 40% of the human need in food and from 40 to 50 % in protein and carbohydrates is satisfied [1].

Despite the positive trend in recent years in the agricultural sector of Mongolia, for its further development it is necessary to solve a number of problems related to the vulnerability and dependence of agriculture on natural extreme factors. It is also necessary to promote the conservation and improvement of agricultural land, increase efficiency and food security in the country [2].
Among the ways to increase crop productivity, the leading role belongs to the variety. Extreme climatic and weather conditions require the production of a large number of varieties that differ in their biological and economic characteristics [3].

The main use of wheat grain is for food purposes, so there are increased requirements for the stable formation of high baking qualities. The wheat grain value is determined by the protein amount that it contains and the gluten quality.

Siberian scientists involved in selection have created varieties that are well adapted to the sharply continental climate and possess good baking qualities [4].

The research work was carried out within the framework of the agreement between the Krasnoyarsk SAU and HHK “IngetTolgoy” company (Mongolia).

The purpose of the research is to study the extreme factors influence on the technological indicators of spring wheat grain of Siberian selection on the territory of HHK “IngetTolgoy” company (Mongolia).

2. Research methods or methodology

The research was conducted in the experimental field of HHK “IngetTolgoy” company located in the Bulgan Aimak, Mongolia.

The Bulgan Aimak is located in the steppe and forest zone of Central Mongolia. In the North of Bulgan there are mountain ranges covered with forests of larch, pine, and cedars. The southern regions are flat terrain. Steppes that are characterized by low vegetation cover and do not have a continuous cover are located in the wide intermountain basins. The steppes are dominated by Stipa capilláta and serpentine formations. There are a lot of small-leaved caragana trees among bushes and sagebrush among dwarf semi-shrubs. The climate of the territory is characterized by sharp continentality, aridity, and sharp daily temperature fluctuations, which is reflected in the vegetation and soil cover. The territory of the Bulgan Aimak is crossed by two major river arteries – the Orkhon and the Selenga rivers, which makes it possible to successfully carry out agriculture and agricultural crops cultivation. The well-known “basin effect” [5], which is manifested in an increase in the climate dryness in vast intermountain basins compared to the slopes of mountains and adjacent plains, leads to the formation of chestnut soils here. Chestnut soils have the widest distribution within the plains of Mongolia [5].

The soils of the researched territory are represented by dark chestnut low-power light loam soil on light brown sandy loam [6].

Chestnut soils develop in the sub-boreal (semiarid) climate which is characterized by warm dry summers and cold winters with little snow cover. They are formed in the zone of dry steppes under the canopy of low-growing sparse complex grass cover in the composition of which sagebrush plays a significant role. The degree of coverage is 50-70%; it decreases as the zone climate becomes drier. The main features of the soil formation process in this zone are slow rates of humus formation and weak leaching of the profile from carbonates and easily soluble salts. Subtypes of chestnut soils, from dark chestnut to light chestnut, consistently reflect the increasing aridity of the bioclimatic mode [7]. They differ in the content of humus in the surface layer: dark chestnut – 3-6%, chestnut – 2-3%, light chestnut –1.5-2% [8]. In soils of light granulometric composition (light loam, powdery sandy loam), the humus content is different: dark chestnut – 2.5-3%, chestnut – 1.5-2.5%, light chestnut – 1.0-1.5%.

The objects of research are zoned varieties of soft spring wheat of Siberian selection:

Novosibirskaya – 15. The originator and patentee is the State scientific institution Siberian research institute of crop production and selection, Siberian branch of Russian academy of agricultural sciences. Lineage is inter-varietal step hybridization (Bezenchukskaya 98 x Irtyshanka 10) x (Tulunskaya 10) x (Novosibirskaya – 22)). The variety is lutescensc. The bush is half-upright. The culm is filled weakly, with a strong pubescence of the upper node. Flag leaf is with a strong waxy coating. The ear is cylindrical, with medium density, white. The shoulder is straight of medium width. The grain is ovoid, colored. The weight of 1000 grains is 34-36 g. Early-maturing, vegetation period is 75-83 days. It is resistant to lodging. Baking qualities are excellent. It belongs to the strong wheat. It is moderately susceptible to hard smut and highly susceptible to brown and stem rust, powdery mildew.
Kantegirskaya – 89. The originators are the State scientific institution Siberian research institute of crop production and selection and the State scientific institution Research institute of agricultural problems of Khakassia. Lineage is individual selection from a third generation hybrid population Novosibirskaya – 67 x Milturum 553. The variety is albidum. The ear is cylindrical, with medium length and density, white. The grain is of medium size. The weight of 1000 grains is 29-35 g. The grain is elongated, with pubescent base, shallow groove. It is mid-seasonal; the growing season is 78-94 days. It is drought-resistant. The resistance to lodging is above average – high. Baking qualities are excellent. It is strong. The variety is susceptible to dusty smut, rust diseases, powdery mildew and Septoria.

Novosibirskaya – 31. The originator and patentee is the State scientific institution Siberian research institute of crop production and selection, Siberian branch of Russian academy of agricultural sciences. It is the medium-early variety, valuable in quality. The plant is medium-tall. The culm is poorly filled. The ear is pyramidal, with loose-medium density, white, with short awn-like processes at the end. The grain is colored. The weight of 1000 grains is 32-41 g. The bush is half-upright – intermediate. It is resistant to lodging. The growing season is from 72 to 95 days. It is medium-drought resistant. The average yield in the region is 32.1 C / ha, which is 2.5 C / ha higher than the average standard. Baking qualities are good. It is the valuable wheat. It is moderately susceptible to brown rust and Septoria. It was strongly affected by the loose smut in the field conditions.

The experimental field is located on the land of HHK “IngetTolgoy” company (Mongolia).

All the studied varieties of spring wheat were sown in three-fold repetition. The site was cultivated before sowing.

The seeding of wheat varieties of Siberian selection was carried out with a seeding-machine SZS-2.1 to a depth of 6 cm, the seeding rate is 4 million germinating grains per ha.

The recording was performed using generally accepted methods and existing State Standards. Technological indicators of grain quality were determined by the following criteria: the quantity and quality of gluten according to State Standard 13586.1-68; the general assessment of grain quality according to State Standard R 52554-2006; the weight of 1000 grains according to State Standard 10842-89.

Statistical processing of the obtained data was performed by the method of dispersion and correlation analysis [9,10].

3. Results and discussion
The soil temperature during the observation period was high both in the arable and sub-arable horizons (figure 1), which puts forward special requirements for varieties not only for drought resistance, but also for heat resistance.

![Figure 1. Soil temperature in the arable and sub-arable horizons, 0°C.](image-url)
Soil temperature was measured in three phases of plant development – the germination phase, the tillering phase, and the milky-waxy ripeness phase. During the period of germination and milk-wax ripeness, the soil temperature in the arable and sub-arable horizons was almost at the same level, and during the tillering period there was a severe drought and the soil temperature was kept above 30°C and reached 36.5°C, which had a significant impact on the grain technological quality.

The grain quality technological indicators depend on the wheat variety, soil and climatic conditions and agricultural techniques of cultivation. In extreme conditions of spring wheat growing, the largest grain was obtained from the Novosibirskaya – 31 variety, the mass of 1000 grains was 32.38 g. The smallest grain was formed by the Novosibirskaya – 15 variety, the weight of 1000 grains was 25.26 g.

The analysis of grain on technological indicators revealed (table 1) that Selenge variety has the lowest vitreousness index – 68 %. The varieties of spring wheat Novosibirskaya – 15 and Tsagaan dagliy received the same indicators – 70 %. The highest value of vitreousness was observed in varieties: Novosibirskaya – 31 – 78% and Kantegirskaya – 89 – 74 %.

**Table 1.** Technological indicators of spring wheat grain.

| Variety             | Weight of 1000 grains, g | Vitreousness, % | Nature, g/l | Protein, % | Gluten, % |
|---------------------|--------------------------|-----------------|--------------|------------|-----------|
| Novosibirskaya – 15| 25.26                    | 70              | 700          | 16.96      | 22.56     |
| Novosibirskaya – 31| 32.38                    | 78              | 800          | 19.38      | 31.66     |
| Kantegirskaya – 89 | 31.53                    | 74              | 750          | 17.92      | 26.55     |
| Tsagaan dagliy     | 31.24                    | 70              | 800          | 16.66      | 21.57     |
| Selenge             | 31.85                    | 68              | 800          | 16.64      | 21.43     |

Grain vitreousness characterizes the consistency of its endosperm, indicates to the protein or starch character of the grain. When evaluating the technological qualities of grain, the concept of “condition” is used. Conditions are an integral part of the grain standards; these are the technical requirements for grain and its quality indicators. Basic conditions are quality standards, which the mature, healthy grain and seeds must meet. Basic conditions are set for a group of indicators, including nature and gluten.

Nature shows the degree of grain being well-filled. A well-filled, full-weight grain has a heightened nature. For wheat, the basic condition of the grain nature should be at least 750 g/l.

Varieties of Siberian selection have the high nature that exceeds the basic requirements; the highest indicator for the Novosibirskaya – 31 variety is 800 g/l.

The protein content of wheat grains of different varieties is shown in figure 2.

**Figure 2.** Protein content in wheat grains of different varieties, %.
As a result of the conducted research, it was found that the protein content in the grain is from 16 to 20%. Grain varieties of Siberian selection, obtained in the soil and weather unfavorable conditions on the land use territory of HHK “IngetTolgy” company, has a high protein content, compared with varieties cultivated on the farm and, accordingly, a high gluten content, which determines its value for baking.

The gluten content of wheat grains of different varieties is shown in figure 3.

![Gluten content of wheat grains of different varieties](image)

**Figure 3.** The gluten content of wheat grains of different varieties.

The largest amount of gluten was formed in the varieties Novosibirskaya – 31 – 31.66 % and Kantegirskaya – 89 – 26.55% (figure3).

In addition to the amount of gluten, its quality was evaluated. The quality of gluten is understood as a set of its physical properties: elasticity, extensibility, resiliency, ability to swell, as well as the ability to maintain these properties during washing and subsequent rest. Elasticity is the property of gluten to return to its original position after stretching or pressing. If, after applying the deforming force, the gluten lump does not have the ability to resist and does not restore the original configuration, then gluten is considered unsatisfactory. With gluten being very elastic, the dough turns out to be difficult to loosen and tear, so excessive or insufficient elasticity is undesirable. Depending on elasticity, gluten is divided into 3 groups: group 1 – gluten with good elasticity. It makes it possible to obtain bread with good form stability, sufficiently loosened, with a large volume output, with a uniform and thin-walled porosity. Group 2 is gluten with satisfactory elasticity. It has a good water-holding capacity, which determines the production of bread in most cases of good quality. Group 3 is gluten very strong or with weak elasticity, floating, which does not allow to get good quality bread.

State Standard approved the classification of grain by gluten quality. These indicators are taken into account both when creating varieties, deciding on their zoning, and when evaluating commercial grain. It is believed that the “strong” wheat improvers include grain with gluten of 28% and higher, in the quality of group I (45-75 device units). The “valuable” that act as a valuable raw material for use in pure form when obtaining good-quality bread include varieties with gluten of 23% and higher, in the quality of group II (80 - 100 device units). The “weak” include grain that needs improvement, with a gluten quality of 105 or more device units and form group III. The “filler” varieties include wheat that occupies an intermediate position in quality between “valuable” and “weak”, which is used in its pure form for baking or for grading to “strong”.

Indicators of gluten quality of Siberian selection grown in the land of HHK “IngetTolgy” company show that the highest quality gluten – group I – good gluten is formed by Novosibirskaya – 31 variety.
Summarizing the obtained results, it can be noted that Siberian selection varieties provide the obtaining of food wheat grain (class 1 and 2) according to nutritional value (protein) and baking qualities (gluten). The purchase price for food grain of this quality is significantly higher.

4. Conclusions
As a result of scientific research in extreme conditions on the territory of land use of HHK “IngetTolgooy” company (Mongolia), the best technological qualities of grain were obtained from the spring wheat variety of Siberian selection Novosibirskaya – 31.

The analysis of technological indicators of wheat grain quality revealed a significant difference: varieties of spring wheat grown in experimental farms in Mongolia were inferior to Siberian varieties in terms of protein and gluten content. The largest amount of gluten was formed in Novosibirskaya – 31 variety and amounted to 31.66 %; and this variety also had the highest protein content in the grain – 19.38 %.

Taking into account the proximity of certain Siberian regions to Mongolia and the presence of similar extreme factors affecting grain crops makes it possible to expand further scientific research.

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