

Yield and seed structure of the spring wheat

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We presented analysis of the influence of spring wheat seeds sowing qualities on the yield. Experimental studies were carried out in 2010-2017 in Altai Krai. The seed divided into fractions in the air stream differs significantly in its characteristics. The ratio of fractions significantly depends on the conditions of the year and has a significant impact on the formation of the potential yield of spring wheat. Seeds isolated at an air speed of 8 m/s are a highly significant limiting factor in achieving the maximum yield of spring wheat. An increase in their share for every 10% in the seed can lead to a yield shortfall of up to 5.5 c/ha. Sowing should be carried out with the most complete seed fractions, with a 1000 grain weight of 31.8-38.0 g, obtained at an air flow rate of 9 m/s. Their share in the seed used by the farms of the region is 34.8 - 52.7%.

Key words: spring wheat, seed structure, yield, Altai Krai

Introduction

The yielding properties of wheat seeds depend on climatic conditions, soil fertility, and agricultural practices. However, the sowing quality of wheat seeds plays a fundamental role in the formation of the yield (Safin, 2017). The problem of assessing the wheat seeds sowing quality indicators has been widely studied; many methods and diagnostic tools are presented (GOST, 2005). On the example of a number of plant species, it has been established that the objective morphological parameters for assessing the quality of seeds is their shape, size and density (Makrushin, Makrushina, 2019). Each variety or hybrid is characterized by the optimal form of seeds, in which the seed has the highest biological properties, which are determined by the anatomical and morphological features of their structure, biochemical composition and physiological state (GOST, 2005).

For seed processing, machines such as spiral separators and gravity tables are used, which perform precise separation according to a specific physical characteristic. Separation of seeds into fractions is possible when using air-sieve grain-cleaning machines configured for fractionation mode, according to two parameters - grain size and aerodynamic properties (Samoylov, 2017). Separators can be divided into mechanical, pneumatic, electrical, optical and X-ray separators according to their operating principle (Beletskiy et al., 2018a; Gryaznov et al., 2018). Fractions with large seeds give more effective results in germination tests than fractions with small seeds (GOST, 2005). The aerodynamic properties of seeds are a combination of qualities that determine the ability of particles to move under the influence of an air flow. The more air resistance the grain experiences, the slower it moves and the earlier it will fall. Separation in an aerodynamic stream allows the separation of the seed into fractions by specific weight. This method ensures the uniformity of seeds during separation of $\pm 3\%$, which makes it possible to separate fractions with a high content of gluten and protein (Beletskiy et al., 2018b).

In the separation process, the air flow rate is regulated by the removal of high-grade seeds to waste. When processing wheat, the air velocity in the pneumatic separation channels usually ranges from 6 to 11 m/s (Sorokin, 2011). For example, for winter wheat seeds, the recommended air flow rate in cleaning machines is at least 8 m / s. It was found that the use of an air flow rate of at least 8 m/s has a positive effect on the sowing quality of wheat seeds (Barysheva et al., 2019).

In the technological processes of grain separation, the division of seed into fractions should be considered one of the agronomic methods of increasing the yield of grain crops. The system of separation measures allows to ensure high yielding properties of grain, but it should also be taken into account that the sowing quality of seeds is an important factor determining the yield. All potential possibilities of the variety can be realized only with high indicators of sowing quality (Lavrinenko, Ogorodnikov, 2011). The purpose of the study was to investigate of the influence of the seed structure on wheat yield.

Methods

Experimental studies to investigate the influence of the sowing qualities of spring wheat seeds on the yield were carried out in 2010-2017 in conditions of production crops of farms in Altai Krai. Every year, before sowing, the sown seeds of different varieties (from 15 to 21) were taken in 18-26 farms and the seeds were divided into fractions on a laboratory pneumatic classifier Petkus K-293. Then, the harvest was counted on the observed fields in the autumn.

In 2010, the relationships between individual seed fractions were determined, and their influence on the maximum yield of spring wheat was assessed. In subsequent years, the dynamics of changes in the ratio of various fractions in the seed was monitored in order to identify the influence of the factor of the year on them. According to the results of measurements, the

degree of closeness of statistical relationships of the evaluated indicators was assessed using the methods of correlation-regression analysis.

Results and Discussion

Based on the results of 2010, statistical relationships were investigated between the weight of 1000 sown grains and the weight of 1000 harvested grains. The resulting constraint equations are shown graphically in Fig. 1.

Thus, the weight of 1000 grains of crop seeds is proportional to the weight of 1000 grains of seed at air flow rates of 9, 10 and 11 m/s. For a speed of 8 m/s, there is no statistically significant relationship between these indicators. Moreover, if the mass of 1000 grains of crop seeds is practically equal to the mass of 1000 grains of yield at $V = 9$ m/s (0.99), then from the mass of 1000 seeds at $V = 10$ m/s it is already 0.89, and from the mass at $V = 11$ m/s is 0.81. As a result of processing the obtained data, a highly significant inverse relationship was established between the proportion of seeds at an air flow rate of 8 m/s in the seed and the maximum yield of spring wheat in the fields. The constraint equation is (1):

$$Y_{\max} = 37.8 - 0.55 * F_{8 \text{ m/s}}, R = 0.98 \quad (1)$$

where Y_{\max} is the maximum yield of spring wheat; $F_{8 \text{ m/s}}$ is the proportion of seeds at an air flow rate of 8 m/s.

As the analysis shows, an increase in the proportion of seed fractions at an air flow rate of 8 m/s for every 10% led to a proportional decrease in the maximum yield of spring wheat by 5.5 c/ha. It is these seeds that significantly limit the yield and are one of the main limiting factors for its increase. These are, as a rule, small, feeble, loose, diseased and infected seeds, which should be removed from the seed without fail.

The dynamics of changes in the average content of various fractions of seeds in the seed of spring wheat and their mass of 1000 grains over the years of research is shown on Figs. 4-5, and statistics are presented in Table 1.

Table 1. The content of various fractions of seeds and the mass of 1000 grains in the seed material of spring wheat

	Weight of 1000 seeds (g) at different air flow rates				Proportion of seed fractions (%) at different air flow rates			
	8 m/s	9 m/s	10 m/s	11 m/s	8 m/s	9 m/s	10 m/s	11 m/s
2010	28.5	37.9	42.0	46.6	17.6	49.8	28.6	4.0
2011	31.9	40.9	45.6	49.8	25.2	57.9	15.6	1.3
2012	28.6	37.8	42.3	46.3	7.4	51.4	33.4	7.8
2013	26.5	33.3	39.3	43.0	34.4	47.8	12.0	5.0
2014	25.0	31.3	37.6	42.2	8.5	42.0	44.1	5.2
2015	22.1	31.3	37.6	43.1	4.8	22.7	57.8	14.7
2016	23.6	35.2	39.1	46.3	8.0	40.8	45.4	4.9
2017	23.7	31.4	37.3	41.3	15.8	37.9	38.4	6.9
	Statistics							
Mean	26.2	34.9	40.1	44.8	15.2	43.8	34.4	6.2
-95%	23.5	31.8	37.6	42.4	6.6	34.8	21.5	2.9
+95%	29.0	38.0	42.6	47.2	23.8	52.7	47.3	9.5
σ	3.3	3.7	2.9	2.9	10.3	10.7	15.4	3.9
C_v , %	10.7	13.5	8.7	8.3	105.8	114.4	238.4	15.5
SEM	1.2	1.3	1.0	1.0	3.6	3.8	5.5	1.4

Analysis of the data shows that over the years of research, the maximum average size of fractions (43.8%) corresponds to an air flow rate of 9 m/s (confidence interval 34.8-52.7%, variation 114.4%). Fractions have the greatest variability at an air flow rate of 10 m/s. Their average value was 34.4%, with a 95% confidence interval of 21.5-47.3% and a variation of 238.4%. The most stable fraction is registered at air flow velocity of 11 m/s: the average value is 6.2% with confidence interval of 2.9-9.5% and a variation of 15.5%. Moreover, the number of fractions of substandard seeds (at 8 m/s) averages 15.2% (confidence interval 6.6-23.8%, variation 105.8%).

The average weight of 1000 seeds is maximum at an air flow rate of 11 m/s (44.8 g) and decreases to 40.1 g, 34.9 g and 26.2 g at an air flow rate of 10, 9 and 8 m/s, respectively. The variation in the mass of 1000 grains is maximum at an air flow rate of 9 m/s (13.8%), in second place is 8 m/s (10.7%), and at 10 and 11 m/s it is significantly lower (8, 7 and 8.3%, respectively). Moreover, there is a highly significant correlation between the weight of 1000 grains of seeds of various fractions. So, with an increase in the mass of 1000 seeds of seeds at an air flow rate of 8 m/s, the weight of 1000 seeds of seeds of the remaining fractions increases ($R = 0.89, 0.94$ and 0.77 at speeds of 9, 10 and 11 m/s, respectively). Those. the factor of the year proportionally affects the weight of 1000 seeds of all fractions.

The shares of seeds at air flow rates of 8 and 10 m/s are inversely related ($R = -0.91$). The ratio of fractions at air flow velocities of 9 and 10 m/s, 9 and 11 m/s is also inversely proportional ($R = -0.83, R = -0.86$, respectively). And the relationship between the fraction of fractions at an air flow rate of 10 and 11 m/s is directly proportional ($R = 0.72$). That is, depending on the conditions of the year, there is a redistribution of the proportion of seeds of different fractions in accordance with the identified relationships.

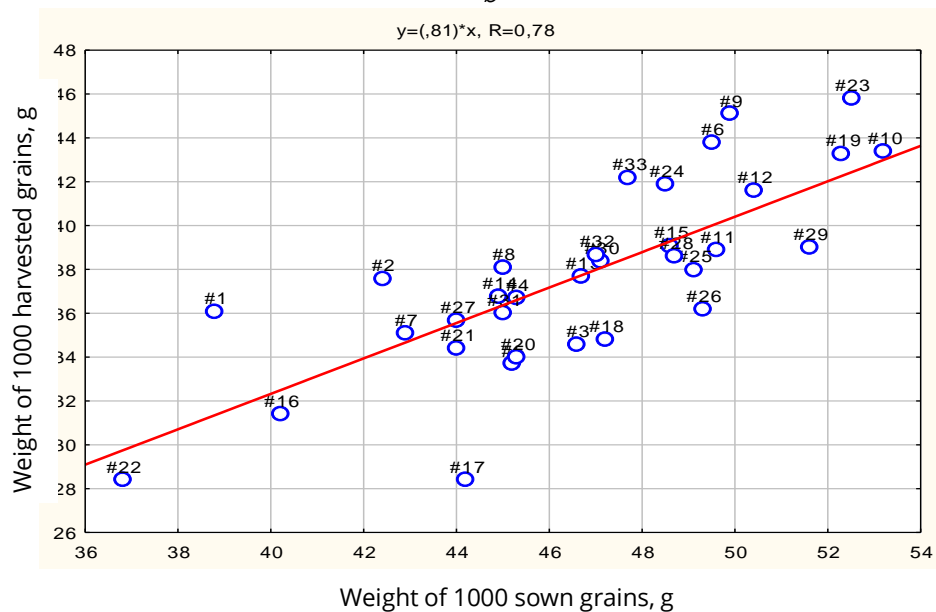
Taking into account the above, for sowing, in our opinion, it is categorically impossible to use the seeds of fractions isolated at an air flow rate of 8 m/s. The range of their variation is in the range of 6.6-23.8% with a mass of 1000 grains of 23.5-29.0 g.



a



b



c

Fig. 1. Dependence on 1000 sown grain and 1000 harvested grain mass on air flow rate: a – 9 m/s, b – 10 m/s, c – 11 m/s

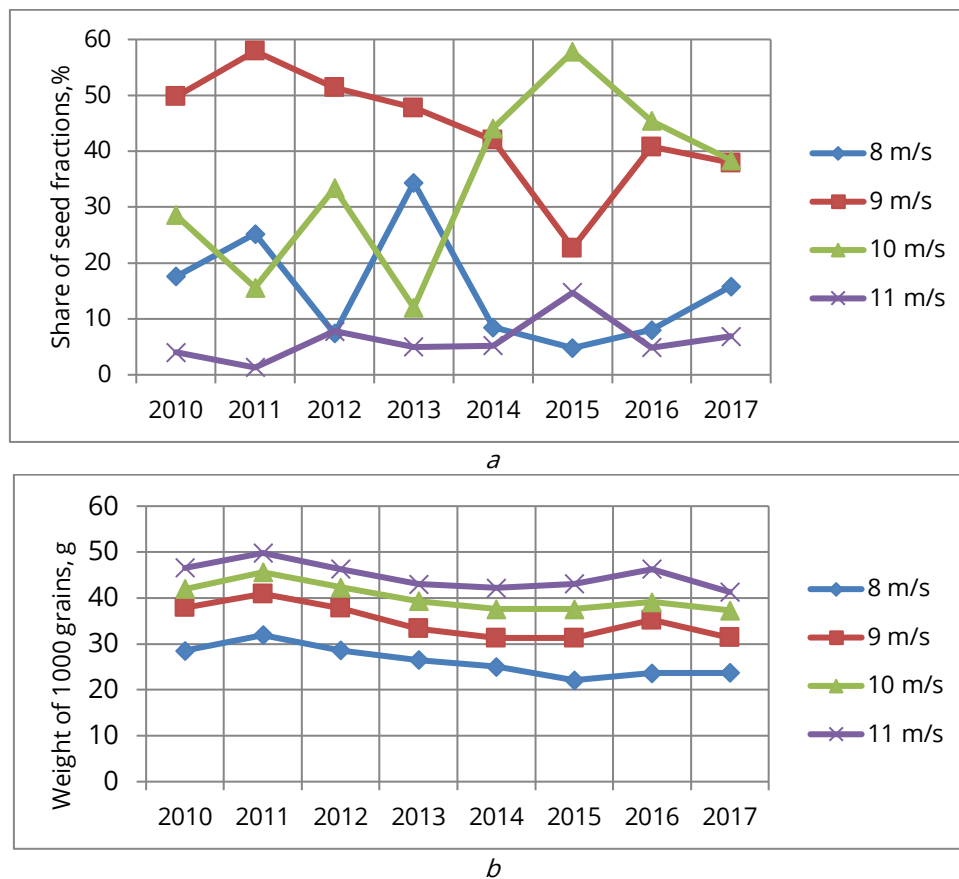


Fig. 2. Proportion of seeds of different sowing fractions (a) and dynamics of the change in the weight of 1000 seeds by the fractions (b)

Conclusion

The seed divided into fractions in the air stream differs significantly in its characteristics. The ratio of fractions significantly depends on the conditions of the year and has a significant impact on the formation of the potential yield of spring wheat. Seeds isolated at an air speed of 8 m/s are a highly significant limiting factor in achieving the maximum yield of spring wheat. An increase in their share for every 10% in the seed can lead to a yield shortfall of up to 5.5 c/ha. Sowing should be carried out with the most complete seed fractions, with a 1000 grain weight of 31.8-38.0 g, obtained at an air flow rate of 9 m / s. Their share in the seed used by the farms of the region is 34.8 - 52.7%.

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