The influence of EXTRASOL on economic valuable characteristics in winter triticale.

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Much recent attention in the agronomical practice has been given to the use of the various biostimulating preparations that influence efficiency, resistance to abiotic and biotic stress, and production quality. One such biostimulator with a complex action is the commercial preparation Extrasol. Extrasol improves feeding elements in a plant, increases seed germination, adjusts enzymatic activity in vegetative cells, accelerates plant development, and reduces infection of phytopathogenic microorganisms, which are reflected in plant productivity.

The action of Extrasol was studied in 2005–06 on the winter triticales Yubileynaya, Sargau, and Student. Experimental sowings were placed in fields of bare fallow in four replicates. We treated vegetative plants at tillering (the beginning of May), a 1% Extrasol solution. The analysis of structure element productivity was carried out using standard techniques. Plant height and spike length were measured. The number of plants, spike productivity, weight of grain from one square meter, and the 1,000-kernel weight were measured. The data were subjected to dispersive analysis.

The extrasol treatment tended to markedly increase the efficiency of productivity parameters, especially 1,000-kernel weight, however, the majority of studied characteristics did not significantly differ from the controls. In 2005–06, the influence of genotype on characteristic prevailed.

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Breeding and genetic analysis for height in spring wheat.

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In the Russian Far East, tall wheat cultivars lodge under the summer monsoon and when grain yield is greater than 2 t/ha. Dwarf cultivars from the U.S., Mexico, Canada, and India were hybridized to create lodging-resistant cultivars. In Khabarovsk, short stalk was inherited very well, but at the same time, negative traits such as wheat drought resistance, suscepibility to *Fusarium* and *Helminthosporium*, and unstable yields, were also inherited.

Materials and Methods. Four F_1–F_2 hybrids, 'ERO-4/Dalnevostochnaya' (ERO-4/DV), 'Opal/Okeanskaya 39' (OPAL/OK39), 'Molodyozhanaya/Primorskaya 1738' (MD/P1738), and 'Molodyozhnaya/Lutescens 47' (MD/L47) were used. The height difference between the cultivars was 12–25 cm. Each cultivar has one or more valuable features. ERO-4 (Brazil) is resistant to disease and drought. Dalnevostochnaya (Russia) is a strong wheat with high quality grain. Opal (Germany) is medium sized, resistant to lodging and disease, and has a large spike. Molodyozhnaya (Russian Federation) has a short stalk and is resistant to lodging. Lutescens 47 (Russian Federation) is productive and has medium resistance to lodging and disease. Okeanskaya 39 and Primorskaya 1783 (Russian Federation) have large spikes and 1,000-kernel weights.

Seed was sown in a field as follows: P_1 (mother) – F_1 – F_2 – P_2 (father). The cultivar Monakinka was used as the check. The height of the parentals and check were determined from 20–30 plants, 15–20 plants of the F_1, and 69–95 in the F_2. Variation within the rows was calculated according to Dospekhov (1973), predomination degree (hp) according to Griffing (1950), heterosis using Omarov (1975), transgression frequency according to Voskresenskaya and Shpot (1967), heritability (H^2) using Warner (1971), and the number of genes according to Rokitsky (1978). The degree of conformity with theoretically expected results was measured by a X^2 test.

Results and Discussion. The efficiency of gene transfer depends on the inheritance and degree of variability of the trait. Three F_1 hybrids inherited height from a dwarf parent; another hybrid (ERO-4/DV) from a tall parent (Table 1, p. 116). The 'MD/P1738' hybrid F_1 had a hp = –1.27, indicating superdominance of the dwarf parent. Plant height increased in

Table 1. Heritability of plant height in the parental lines and in the F_1–F_2 hybrid generations. CD+ is complete dominance of the high trait; ID– is incomplete dominance of the low trait; and ED– is extradominance of the low trait.

Hybrid combination	Mean (cm)				hp		Heritability in the F_1
	P_1	F_1	F_2	P_2	F_1	F_2	
DRO-4/Dalnevostochnaya	74.2±1.4	86.0±0.6	83.0±0.9	86.1±1.1	0.98	0.47	CD+
Opal/Okeanskaya 39	75.9±1.1	77.0±0.4	87.6±0.7	86.5±1.3	–0.79	1.21	ID–
Molodyozhanaya/Primorskaya 1738	67.9±1.1	65.4±0.6	84.0±0.8	86.3±0.9	–1.27	0.75	ED–
Molodyozhnaya/Lutescens 47	67.9±1.1	71.9±1.2	77.6±0.8	90.9±0.8	–0.65	–0.16	ID–
Monakinka (check)	90.0±1.2						

the F_2 compared to the F_1 except for the 'ERO-4/DV' cross. Plant height increased by 10.6 cm in the 'OPAL/OK39' F_2, by 18.6 cm in 'MD/P1738', and by 5.7 cm in 'MD/L47' (Table 2). Table 2 shows the height differences in the hybrid F_1s and F_2s. For the 'MD/P1738' cross, the height of the F_2 is greater than in the F_1. Three hybrids have an hp <1. The 'OPAL/O39' hybrid has an hp >1 indicating heterosis. The lack of heterosis proves the necessity of making selections in the early generations. The variability was greater in the hybrid F_2s (Table 3). Factors of genotypic variability, depending on the hybrid, make up 6.3–8.5% and 7.8–10.3% for phenotypic variability.

Table 2. Tall plant heterosis in parental lines and in the F_1–F_2 hybrid generations (* = $p < 0.001$).

Hybrid combination	Tall plant parental deviation (cm)		Heterosis		
	F_1	F_2	Check	F_1	F_2
DRO-4/Dalnevostochnaya	–0.1	–3.1	0.1	–0.1	–3.6
Opal/Okeanskaya 39	–9.5*	1.1	–10.4	–11.0	1.3
Molodyozhanaya/Primorskaya 1738	–20.9*	2.3	–23.9	–24.2	–2.7
Molodyozhnaya/Lutescens 47	–19.0*	–13.3*	–16.3	–20.9	–14.6

Table 3. Variability in plant height in parental cultivars and their hybrids. For the F2 coefficient of variation, the numerator is the phenotypic and the denominator is the genotypic variation.

Hybrid combination	Generation	Variability limit (cm)	Difference max–min (cm)	Variation coefficient (%)
DRO-4/Dalnevostochnaya	P_1	66–88	22	7.9
	P_2	78–94	16	5.8
	F_1	83–91	8	2.9
	F_2	56–95	39	10.3/8.4
Opal/Okeanskaya 39	P_1	65–82	17	6.5
	P_2	73–100	27	7.4
	F_1	73–80	7	2.7
	F_2	70–101	31	7.3/4.8
Molodyozhanaya/Primorskaya 1738	P_1	62–76	14	6.7
	P_2	79–94	15	4.9
	F_1	60–70	10	3.3
	F_2	65–95	30	7.8/6.3
Molodyozhnaya/Lutescens 47	P_1	62–76	14	6.7
	P_2	82–96	14	4.4
	F_1	60–87	27	7.3
	F_2	65–93	28	10.3/8.4

No transgressive segregation was observed in the F_2. The height of the hybrids was within the limit of variation of the paternal cultivars (Table 3) except for the 'ERO-4/DV' hybrid, which varied between 56–95 cm, and the ERO-4 parent was 66–88 cm and the DV parent was 78–94 cm. In this cross, most of the dwarf plants were 10–24 cm shorter than those of the check Monakinka, a difference of 20–35 cm compared to the mean height of the check. Depending on the hybrid combination, shorter plants varied from 10.6–55.6% (Table 4, p. 117). With respect to the check Monakinka, all the hybrids show signs of transgressive segregation (Table 4), which is why it is better to select shorter plants from the hybrid than from the standard check cultivar.

Table 4. Transgressive segregation parameters for plant height in the hybrid F_2s.

Hybrid combination	Minimum height (cm)		Trangression (%) toward			
			Check		< Parent	
	< Parent	Hybrid	Degree	Frequency	Degree	Frequency
DRO-4/Dalnevostochnaya	66.7	60.3	24.6	31.0	9.5	4.6
Opal/Okeanskaya 39	67.0	71.7	10.4	10.6	0.0	0.0
Molodyozhanaya/Primorskaya 1738	61.3	67.3	15.9	20.3	0.0	0.0
Molodyozhnaya/Lutescens 47	61.3	65.0	18.8	55.6	0.0	0.0

Table 5. Plant height in the hybrid F_2.

Hybrid combination	Number of plants	Tall vs. short plants		X_2	Significance level (p)
		actual	theoretical		
Molodyozhanaya/Primorskaya 1738	64	55:9	52:12	0.92	0.50>p>0.25
		13.75:2.25	13:3		
Molodyozhnaya/Lutescens 47	80	33:47	33:45	0.22	0.75>p>0.50
		6.6:9.4	7:9		

In the F_2 hybrids of 'ERO-4/DV' and 'OPAL/O39', the difference in plant height was not large (10–12 cm) and the phenotypic distribution was close to normal. Hybrids 'MD/P1738' and 'MD/L47' differed by as much as 25 cm. Plants that were two standard deviations less than the parental were considered undersized or tall. For the undersized plants, the interval was 58.8/77 cm (MD) and for the tall plants, it was 78.1/94/5 cm (P1738). The ratio was close to 13:3 for the 'MD/P1738' F_2 and 7:9 for the 'MD/L47' F_2 (Table 5).

The number of genes controlling plant height in the 'MD/P1738' hybrids was 2.0 and in the 'MD/L47' hybrids was 2.24 (Table 6), which should be two and three genes, respectively. The other two crosses have one gene and wheat phenotypic activity makes hybrid analysis difficult. The heritability coefficient H^2 is a sufficient indicator for the efficiency of breeding for a characteristic. The highest H^2 values were in the 'ERO-4/DV' hybrids (0.70), followed by 'MD/P1738' (0.67), and 'MD/L47' (0.66) (Table 6). Thus, the lack of heritability and the high degree of transgressive segregation and the coefficients of genotypic variation combined with high heritability need to be considered for breeding plants that are dwarf or resistant to lodging.

Table 6. Plant height heritability in the parental lines and the F_1–F_2 hybrid generations.

Hybrid combination	Cultivar and hybrid variation (σ^2)				Heritability	Number of genes
	P_1	F_1	F_2	P_2		
DRO-4/Dalnevostochnaya	34.65	24.90	6.07	72.08	0.70	0.40
Opal/Okeanskaya 39	24.62	40.49	2.71	40.62	0.44	0.49
Molodyozhanaya/Primorskaya 1738	20.54	16.71	4.69	41.61	0.67	2.00
Molodyozhnaya/Lutescens 47	2.54	15.74	27.47	63.34	0.66	2.24

From our studies, the following lines were selected from the hybrid populations: 'ERO-4/DV' lines 131 and 132; 'OPAL/O39' lines 408, 721, 755, and 774; 'MD/P1738' lines 499, 502, and 523; and 'MD/L47' lines 402, 426, and 438. All these lines are 1.5–2 times more productive than the check Monakinka, resistant to lodging and disease, and have optimal height (75–80 cm) for the conditions of far-eastern Russia.

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Races of Puccinia graminis f. sp. tritici in Russian Federation in 2006.

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Monitoring the race composition of the wheat stem rust pathogen is done annually in the same fields of three regions of the Russian Federation; Central Russia (Moscow Region), the Northern Caucasus (Rostov Region), and Western Siberia (Tomsk Region). Development of disease may vary according to climatic conditions and the source of infection. Long-term observations indicated that infection on wheat and other grains generally appeared in the fields as separate groups of plants infected by stem rust. Under conditions unfavorable for development of the fungus, plants infected by rust were usually found on separate wheat cultivars with high susceptibility to pathogen. For example, the stem rust pathogen is found yearly in Rostov Region on wheat cultivars Albidum 28 and Albidum 43. However, considering the high infection potential of the pathogen, monitoring virulence and race composition of the fungus is extremely important to predict the appearance of new pathogen races in order to control development of stem rust epidemics.

The 2006 growing season was relatively favorable for development of wheat stem rust. Separate hotbeds of the pathogen were found on many wheat and barley cultivars in Central Russia and the Northern Caucasus. In Northern Siberia, only aeciospores were found on barberry. No large infection was observed, possibly explained by an insufficient amount of inoculum.

Races were determined by infecting 16 wheat lines with known resistance genes with monouredinial fungal isolates (Roelfs and Martens 1988). Fourteen races of *P. graminis* f.sp. *tritici* were identified in populations of the fungus from different regions of the Russian Federation. Races that occurred with a frequency of 8% or higher were referred to as dominant and those with lesser frequency as rare (Lekomtseva et al. 2007). Races TKNT (46%), TKNS (11%), and TKPT (8%) dominated in 2006. Races TKST and TTNT had occurrence frequencies of 7% (Table 1).

Table 1. Races of *Puccinia graminis* f. sp. *tritici* in the Russian Federation in 2006.

Race	Susceptibility of *Sr* genes	Number of isolates	%
KJNT	21, 9e, 7b, 6, 8a, 36, 30, , 9a, 9d, 10, Tmp	1	1
RKNT	5, 21, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp	3	4
TKNT	**5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp**	**34**	**46**
TKNS	**5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10**	**8**	**11**
TKPT	**5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 13, 9a, 9d, 10, Tmp**	**6**	**8**
TKST	**5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp**	**5**	**7**
TKKT	5, 21, 9e, 7b, 6, 8a, 9g, 36, 30,13, 9a, 9d, 10, Tmp	3	4
TFNT	5, 21, 9e, 7b, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp	1	1
TTNT	**5, 21, 9e, 7b, 11, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp**	**5**	**7**
TTPT	5, 21, 9e, 7b, 11, 6, 8a, 9g, 36, 30,13, 9a, 9d, 10, Tmp	4	5
RTPT	5, 21, 7b, 11, 6, 8a, 9g, 36, 30,13, 9a, 9d, 10, Tmp	1	1
PKQT	5, 9e, 7b, 6, 8a, 9g, 9a, 9d, 10, Tmp	2	3
TTST	5, 21, 9e, 7b, 11, 6, 8a, 9g, 36, 9b, 30, 9a, 9d, 10, Tmp	1	1
TJST	5, 21, 9e, 7b, 6, 8a, 36, 9b, 30, 9a, 9d, 10, Tmp	1	1
Total		75	100