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Ecological study of early ripe corn hybrids in the steppe zone of the lower Volga

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Abstract
The article considers the results of statistical processing of a field experiment that includes 17 corn hybrids (FAO 100 - 199) and 22 indicators characterizing vegetative, generative traits and biochemical composition of grain. As for the cultivar factor (A), the differences in all variants were significant. According to the year factor (B), the differences in characteristics are not significant: shoots - panicle flowering, attachment height of the upper ear, content of nitrogen-free extractives. The interaction "genotype - environment" was not reliably revealed only by the content of nitrogen-free extractive substances. The output of gross energy in grain for corn hybrids varies within 39.11... 82.90 GJ/ha. The contribution of nutritious grains to the gross energy output was the following: protein - 4.73 - 10.69 GJ/ha, fat - 4.44 - 8.03 GJ/ha, fiber - 0.55 - 2.05 GJ/ha, nitrogen-free extractive substances - 29.40 - 62.70 GJ/ha. The experiment revealed a high total contribution to the total variability of the variety (A) factors and the year - genotype interaction (AB), while the effect of the year factor (B) does not exceed 7%.

Keywords: corn, hybrid, trait, interphase period, height, the weight of 1000 grains, content, protein, fat, fiber

Introduction

The problem of early ripe corn selection is of great importance for the Lower Volga region, since it determines the production of grain with decreased harvesting moisture, which significantly reduces costs, and also allows you to expand the sowing area [10]. Apparently, agrotechnical features are also of a certain importance, since the earlier emptying of the fields allows timely and efficient implementation of a set of measures for autumn tillage [9].

Materials and Methods

The experimental part was carried out on the experimental field of the FSBSI ROSNIISK "Rossorgo" in 2017 - 2019. In terms of granulometric composition, the chestnut soils of the experimental site are heavy loamy coarse dusty and silty. These soils have a high water-holding and water-retaining capacity. The humus content in the arable layer is 3.38-3.56 %. Its content decreases with depth. The soil supply with mobile phosphorus is low, and high with potassium. The hydrothermal coefficient during the period May - September was the following: 2017 - 0.91; 2018 - 0.69; 2019 - 0.82.

When studying corn hybrids, the plot area is 15.4 m2. Row spacing - 0.7 m. Three times repetition. The planting density of corn plants for harvesting was 45 thousand pieces/ha. Sowing period for corn is the second decade of May, the phase of corn emergence was recorded on May 25 - 28. Corn was harvested during the third decade of September. The records and measurements of morphometric parameters, biochemical composition of seeds was carried out according to generally accepted methods [1-5, 8]. Statistical processing of the experimental material was carried out in accordance with the methodological guidelines [6, 7].

Results and Discussion

Early ripening hybrids are characterized by relatively short interphase periods in the experiment (table 1). Moreover, the end of the flowering phase of the cobs (the appearance of threads) falls on the beginning of the third decade of July. The hybrids included in the experiment belong to the early maturing group of corn, however, there was a significant difference in the duration of interphase periods (factor A). The difference in the year factor (B) was not established for the period "seedling - panicle flowering". The difference in

plant height and ear attachment height (factor A) is significant at the 5% level. The hybrids Nur, Mashuk 150 MV and RNIISK 1 are distinguished by their relative tallness and ear attachment.

Table 1: Duration of interphase periods and plant heights of corn hybrids depending on the year of research, 2017-2019

	Hybrid	Shoots - appearance of panicles, days	Shoots - panicle flowering, days	Shoots - cob flowering, days	Plant height, cm	Height of the upper cob attachment, cm
	Factor A					
1	Kubansky 101 SV	44,3	48,2	49,0	192,7	70,5
2	Ross 140 SV	44,2	49,2	50,0	194,5	72,5
3	RNIISK-1	46,2	49,7	51,5	218,5	82,6
4	Mashuk 150 SV	48,8	52,3	52,7	223,6	88,1
5	Nur	50,2	54,0	55,3	226,7	92,1
6	Uralsky 150	48,7	51,9	53,3	185,5	54,7
7	Ladozhsky 150 MV	45,9	51,5	51,9	184,6	56,6
8	Mashuk 170 MV	46,1	50,0	50,9	165,1	51,1
9	Mashuk 171 MV	48,3	51,4	53,0	180,0	54,6
10	Mashuk 175 MV	49,9	54,0	55,7	175,9	63,2
11	Katerina SV	52,1	56,4	57,7	181,7	64,9
12	Mashuk 185 MV	45,3	48,8	49,3	167,6	46,3
13	Rodnik 179 SV	41,0	47,0	47,7	155,0	34,5
14	Rodnik 180 SV	44,3	48,3	50,3	154,2	37,9
15	Agatha SV	46,0	48,7	50,0	159,2	41,5
16	Darina MV	48,0	50,3	49,0	189,6	55,2
17	Stimul	50,0	53,8	54,0	176,9	52,4
	Factor B					
	2017	47,2	51,1	52,2	185,6	60,3
	2018	46,7	50,1	51,4	185,1	60,0
	2019	47,1	51,0	52,0	181,9	59,5
	$NSR_{0,05}$					
	NSR (A)	1,00	1,04	0,1	3,91	1,42
	NSR (B)	0,42	ns	0,50	1,64	ns
	NSR (AB)	1,73	1,80	0,20	6,76	2,46

Different origins of the hybrids, as well as the years of their creation and germplasm, determined the reaction of genotypes to the experiment conditions, which was reflected in their significant difference for generative traits, for factors A, B and the interaction genotype - AB environment (Table 2). It should be noted that more than 100.0 g of grain per ear was formed by the hybrids Nur, Uralsky 150, Darina MV. And the largest mass of 1000 grains is noted among the hybrids - Kuban 101 SV, Rodnik 179 SV, and Uralsky 150. The largest number of grains per ear was found in the hybrids Nur, Agata SV, and Darina MV. Significant grain moisture during harvesting of Darina MV and Stimul hybrids will increase the cost of drying after harvesting to a certain extent.

Table 2: Parameters of generative traits depending on the year of research, 2017-2019

	Hybrid	1	2	3	4	5	6	7	8	9	10	11
	Factor A											
1	Kubansky 101 SV	13,1	11,7	3,6	14,4	25,1	363,0	121,7	91,2	261,5	23,3	75,1
2	Ross 140 SV	15,7	15,2	3,6	14,4	31,8	458,8	88,2	71,4	155,9	23,2	81,1
3	RNIISK-1	16,6	15,6	3,8	15,1	32,2	488,2	114,2	93,4	190,8	19,2	81,4
4	Mashuk 150 SV	17,3	15,7	3,4	15,1	31,7	477,6	122,7	99,1	206,0	20,1	80,8
5	Nur	17,0	15,9	3,5	15,8	33,8	533,3	132,4	103,3	212,4	20,6	78,0
6	Uralsky 150	15,7	13,7	3,7	15,1	30,1	464,7	120,9	102,8	223,8	20,3	79,6
7	Ladozhsky 150 MV	15,9	13,3	3,8	14,1	27,9	397,4	91,0	76,0	195,0	15,5	83,6
8	Mashuk 170 MV	16,0	12,4	4,0	14,2	25,4	360,9	96,8	77,7	212,2	15,6	80,1
9	Mashuk 171 MV	18,2	15,0	3,7	14,2	31,3	442,2	107,9	91,3	207,2	15,5	84,6
10	Mashuk 175 MV	17,3	14,2	3,7	14,0	31,3	438,7	115,0	91,0	218,9	15,9	79,1
11	Katerina SV	15,7	13,4	4,0	14,7	29,9	446,7	101,2	84,4	196,0	15,8	83,1
12	Mashuk 185 MV	15,3	13,7	3,8	12,7	30,5	387,9	96,0	79,2	200,6	17,9	82,7
13	Rodnik 179 SV	16,4	15,0	4,1	13,1	32,3	424,2	114,9	90,9	213,7	17,6	78,6
14	Rodnik 180 SV	16,9	15,0	4,0	13,3	32,1	426,8	120,6	97,8	232,9	18,7	80,9
15	Agatha SV	17,7	16,2	4,0	15,1	33,6	507,4	111,5	98,0	174,7	21,3	78,9
16	Darina MV	19,2	16,8	4,3	14,9	37,3	557,8	144,2	114,9	210,2	26,2	79,6
17	Stimul	16,4	14,4	4,3	14,7	33,2	485,6	124,7	94,1	197,4	26,2	75,2
	Factor B											
	2017	16,7	14,9	3,9	14,6	32,2	471,2	116,5	92,6	198,8	20,1	79,5
	2018	16,5	14,5	3,8	14,2	31,2	445,7	110,8	91,5	210,2	19,2	80,5
	2019	16,2	14,1	3,9	14,4	29,9	435,0	112,2	88,8	210,5	19,3	80,4
	$NSR_{0,05}$											

	NSR (A)	2,44	0,39	0,09	0,26	0,36	9,8	2,41	1,96	3,78	0,42	1,068
	NSR (B)	2,19	0,16	0,04	0,11	0,15	4,12	1,01	0,83	1,59	0,18	0,71
	NSR (AB)	0,76	0,67	0,15	0,45	0,62	16,98	4,17	3,40	6,54	0,74	3,0

Note: 1. The cob length, cm; 2. The length of the cornified part of the ear, cm; 3. The cob diameter, cm; 4. The number of grain rows on the cob, pcs; 5. The number of grains in a row, pcs; 6. The number of grains on the cob, pcs.; 7. Weight of corn cob with a core, g; 8. The mass of the cob grain, g; 9. Weight of 1000 grains, g; 10. Harvesting moisture, %; 11. Grain yield, %.

The content of nutrients in grain is significantly influenced by the morphological characteristics of grain, which depend on varietal growing conditions [10-14]. By its nature, corn is not a high-protein crop [9]. The main components of corn storage proteins are alcohol-soluble zein (about 50% of all proteins) and alkaline-extractable glutein (about 30%). The studies by many authors have shown that the protein content increase in grain leads to the content increase of all protein components. The main criterion for the quality of grain is the presence of protein, essential amino acids and fat. The amount and quality of protein is genetically determined and the inheritance of the trait is matroclinous, that is, the high-protein maternal form causes a higher protein content in the grain, since 80% of the protein is concentrated in the endosperm, which includes two sets of maternal genes and one set of paternal ones.

The experiment revealed a significant difference in the indicators of the biochemical composition of grain, in the content of protein, fat, ash, and fiber. In terms of nitrogen-free extractive substance content, differences were revealed only between varieties, while the year factor (B) and the interaction factor "genotype - environment" (AB) turned out to be insignificant (Table 3). For Ladozhsky 150 MV, Katerina SV, and Darina MV hybrids the protein content in grain was relatively higher than in other hybrids.

Table 3: Biochemical composition of corn hybrids depending on the year of research, 2017-2019

	Hybrid	Content, %					Grain yield, t/ha
		protein	fat	cellulose	ash	NFES	
1	Kubansky 101 SV	8,48	4,95	2,25	1,24	83,09	2,45
2	Ross 140 SV	9,87	5,01	1,77	1,13	82,22	3,68
3	RNIISK-1	8,71	4,98	2,4	1,04	82,88	3,37
4	Mashuk 150 SV	8,99	4,65	1,84	1,09	83,83	3,20
5	Nur	8,64	4,75	2,17	0,99	83,45	2,89
6	Uralsky 150	8,17	5,29	1,95	1,25	83,34	3,57
7	Ladozhsky 150 MV	10,18	4,77	2,89	1,36	80,92	4,03
8	Mashuk 170 MV	9,49	4,34	2,43	1,27	82,47	4,09
9	Mashuk 171 MV	9,97	4,69	2,79	1,26	81,28	5,25
10	Mashuk 175 MV	9,90	4,90	2,47	1,32	81,95	3,99
11	Katerina SV	10,83	4,27	2,84	1,27	80,72	3,86
12	Mashuk 185 MV	9,23	4,46	1,61	1,05	83,64	4,45
13	Rodnik 179 SV	9,55	4,29	1,01	0,95	84,20	3,97
14	Rodnik 180 SV	9,04	4,63	0,91	0,92	84,51	4,26
15	Agatha SV	8,90	4,53	1,07	0,96	84,55	4,09
16	Darina MV	10,02	5,00	1,04	0,99	82,95	3,04
17	Stimul	8,68	4,62	1,16	0,89	84,65	4,57
	Factor B						
1	2017	9,11	4,89	1,94	1,11	82,94	4,15
2	2018	9,26	4,65	1,78	1,13	83,29	4,07
3	2019	9,63	4,60	2,04	1,10	82,66	4,00
	$NSR_{0,05}$						
	NSR (A)	0,20	0,12	0,05	0,13	1,79	0,18
	NSR (B)	0,08	0,05	0,02	0,12	ns	0,08
	NSR (AB)	0,24	0,21	0,08	0,21	ns	0,31

The variance analysis of two-factor experience allows you to determine the strength of regulated and unregulated factor influence on the effective indicator. The strength of the factor influence is defined as the share of factorial variation in the total variation [7]. The contribution of factors to the total variability in the experience varies depending on the trait (table 4). More than 50% share of the hybrid factor (A) influence was revealed in the following features: plant height, ear attachment height, harvest moisture, protein, fiber, ash content (table 4). The contribution to the total variability of the year factor does not exceed 7% in all respects. The share of genotype-environment interaction influence was more than 50% in 10 features, and less than 30% in 2 features.

Table 4: Contribution of factors to the total variability of the studied traits in two-factor experience, 2017-2019

	Feature	Factor			
		A	B	AB	Unaccounted for (random)
1	Shoots - emergence of panicles	35,15	0,01	60,65	3,91
2	Shoots - flowering of panicles	32,66	0,02	61,81	4,49
3	Shoots - cob flowering	33,36	0,01	62,09	4,54
4	Plant height	65,10	0,40	32,70	1,80

5	Height of the upper cob attachment	67,54	0,01	32,05	1,80
6	Cob length	45,18	1,3	49,38	4,14
7	Corn cob length	46,26	2,73	47,76	3,25
8	Cob diameter	49,88	0,06	43,81	6,25
9	Number of grain rows	26,80	1,13	69,80	3,27
10	Number of grains in a row	48,44	5,07	44,68	1,81
11	The number of grains on the cob	38,12	3,13	57,72	1,03
12	Weight of grains with a core from 1 cob	33,45	0,93	64,82	0,80
13	Grain weight from 1 cob	28,81	0,61	69,76	0,80
14	Weight of 1000 grains	25,98	1,54	71,84	0,64
15	Harvesting moisture	77,09	0,97	21,02	0,92
16	Grain yield	39,17	1,28	44,26	15,37
17	Protein content	52,73	5,15	38,55	3,57
18	Fat content	28,21	6,11	61,34	4,34
19	Fiber content	59,62	1,51	38,64	0,23
20	Ash content	65,35	0,18	33,15	1,32
21	NFES content	28,27	1,33	18,51	51,89
22	Grain yield	24,70	0,04	72,31	2,95

The output of gross energy with the grain yield of the hybrids varies in the range of 39.11... 82.90 GJ/ha. Moreover, the largest share in the energy value is provided by the content of nitrogen-free extractive substances 29.4... 62.7 GJ/ha, while the contribution of protein is 4.73... 10.69 GJ/ha, fat - 4.44... 8.03 GJ/ha, and fiber - 0.55... 2.05 GJ/ha. The highest output of gross energy (more than 70.0 GJ/ha) was obtained with the grain harvest of Mashuk 171 MV, Mashuk 185 MV, and Darina MV hybrids.

Table 5: Output of gross energy for useful substance of corn hybrids (seed-plot for ecological testing), ESPA "Povolzhye", 2020.

Hybrid	Energy by useful substance, GJ/ha				
	total	protein	fat	cellulose	NFES
1. Kubansky 101 SV	39,11	4,73	4,44	0,55	29,40
2. Ross 140 SV	58,41	7,45	5,87	1,83	43,26
3. RNIISK-1	53,42	7,02	5,16	0,93	40,31
4. Mashuk 150 SV	51,01	6,892	5,20	1,73	37,39
5. Nur	46,02	6,111	4,72	1,74	33,45
6. Uralsky 150	56,05	6,230	4,89	1,02	43,91
7. Ladozhsky 150 MV	63,55	7,72	5,77	0,88	49,18
8. Mashuk 170 MV	65,86	8,17	8,03	1,71	47,95
9. Mashuk 171 MV	82,90	10,69	7,46	2,05	62,70
10. Mashuk 175 MV	63,07	8,14	5,65	1,83	47,46
11. Katerina SV	61,16	7,66	6,04	0,97	46,49
12. Mashuk 185 MV	71,96	8,61	7,65	1,73	53,97
13. Rodnik 179 SV	63,52	8,37	6,88	1,90	46,37
14. Rodnik 180 SV	68,08	8,95	7,19	1,92	50,02
15. Agatha SV	65,32	9,46	6,44	1,73	47,69
16. Darina MV	47,56	6,62	3,39	1,26	36,31
17. Stimul	71,83	8,71	6,05	2,02	55,05

Conclusions

Thus, the study of early ripe corn hybrids made it possible to establish their difference in vegetative, generative characteristics and biochemical composition of grain, as well as to establish the proportion of the factor influence: hybrid (A), year (B), their interaction (AB), as well as unaccounted for (random) factors. It has been established that the hybrids Mashuk 171 MV, Mashuk 185 MV, Darina MV provide the greatest output of gross energy with the grain yield.

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