Artículo de investigación

Medium-Early Spring Wheat Cultivars Depending on The Level of Mineral Nutrition in The Northern Forest-Steppe of The Tyumen Region

Среднеранние сорта яровой мягкой пшеницы в зависимости от уровня минерального питания в северной лесостепи Тюменской области

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Abstract

This article analyzes the results by the yield and grain quality of two spring wheat cultivars Tyumenskaya Yubileynaya and Tyumenocka, depending on the level of mineral nutrition in the forest-steppe zone of the Tyumen region. The length of the vegetation period corresponded to the climatic conditions of the forest-steppe zone of the Tyumen region. In the reference variant and the variant with 4 tons of NPK per hectare, it was 90 days, and in the variants with 4 and 6 t/ha, it was 92 days. In the reference variant, the average yield of the Tyumenskaya Yubileynaya cultivar over the three years was 3.31 t/ha, and that of the Tyumenocka cultivar — 2.93 t/ha. The introduction of mineral fertilizers for the planned yield of 4 t/ha allowed obtaining the yield for the Tyumenskaya Yubileynaya cultivar equal to 4.14 t/ha, which was by 0.83 t/ha more than in the reference variant. The Tyumenocka cultivar yielded 3.83 t/ha, which was by 0.90 t/ha higher than in the reference variant. Further increasing the dosages of mineral fertilizers to 5 t/ha allowed obtaining 4.73 – 4.72 t/ha for both cultivars, which was by 0.27 – 0.28 t/ha lower than planned yield. The content of gluten in the grain of cultivar Tyumenskaya Yubileynaya in the reference variant was 27.2 %, of the Tyumenocka cultivar — 24.2 %. In the variant with 4 tons of NPK per hectare, an increase in the content of gluten by 9.6 – 10.4 %, respectively, was noted. According to the economic calculations, the most favorable for spring wheat cultivation in the Tyumen region is the level of mineral fertilization equal to 5 tons of NPK per hectare.

Аннотация

В данной статье проанализированы результаты по урожайности и качеству зерна двух сортов яровой мягкой пшеницы Тюменская юбилейная и Тюменочка в зависимости от уровня минерального питания в лесостепной зоне Тюменской области. Установлено, что продолжительность вегетационного периода соответствует природно-климатическим условиям лесостепной зоны Тюменской области. В контрольном варианте и варианте NPK на 4 т/га он составил 90 суток, в вариантах на 4 и 6 т/га – 92 суток. В контрольном варианте сорт Тюменская юбилейная дал урожайность в среднем за 3 года – 3,31 т/га, Тюменочка – 2,93. Внесение минеральных удобрений на планируемую урожайность 4 т/га позволило получить по сорту Тюменская юбилейная – 4,14 т/га, или на 0,83 т/га выше контрольного варианта. Сорт Тюменочка дал 3,83 т/га, что на 0,90 т/га выше контроля. Дальнейшее увеличение доз минеральных удобрений на получение урожайности 5 т/га позволило по обоим сортам получить 4,73-4,72 т/га, то есть на 0,27-0,28 т/га ниже планируемой. Содержание клейковины в зерне у сорта Тюменская юбилейная в контрольном варианте было 27,2 %, у Тюменочки – 24,2%. В варианте NPK на 4 т/га отмечено увеличение клейковины на 9,6-10,4 % соответственно. По экономическим расчётам, наиболее выгодным для возделывания яровой

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Key Words: Spring wheat, cultivar, fertilizers, yield rate, grain quality.

пшеницы в Тюменской области является уровень минерального питания NPK на 5 т/га.

Ключевые слова: яровая пшеница, сорт, минеральные удобрения, урожайность, качество зерна.

Introduction

Breeding spring wheat in scientific and educational institutions of Western Siberia is quite successful. In the register of breeding achievements, the share of foreign-bred cultivars has been reduced to zero. Moreover, the list of varieties bred in other regions of the country reduces every year, which is due to the peculiarities of climatic conditions of Western Siberia and the productivity of local breeding (Ageeva, 2015; Anosov, 2015; Ageeva, 2017; Belkina, 2017a).

It should be noted that in Western Siberia, along with breeding centers in cities like Omsk, Novosibirsk, Barnaul, and Tyumen, the Omsk State Agricultural University and the Northern Trans-Ural State Agricultural University are successfully engaged in breeding spring wheat. In both institutions, the theoretical basis of wheat breeding is developing, and the cultivars that are mainly valuable and strong in terms of grain quality are created. Out of the 85 wheat cultivars registered in the region, 26 belong to strong, and 40 — to valuable cultivars (Anosov, 2015; Belkina, 2017a; Belkina, 2017b; Belkina, 2017c). A worthy contribution in their creation was made by the above-mentioned educational institutions.

In the last decade, two cultivars of spring wheat — Tyumenskaya Yubileynaya and Tyumenocka — were created at the Northern Trans-Ural State Agricultural University. The first cultivar passed state grade testing and was included in the register of breeding achievements of the West Siberian region (Belkina, 2017b). The second cultivar is still in the state grade testing. Both cultivars are well adapted to the Siberian conditions, and constantly give stable yields of annual herbs and grain predecessors over the years.

Each wheat cultivar implements its yield rate and grain quality potential in the conditions of the technology developed for it. In this regard, simultaneously with passing the new cultivars to State grade testing, the authors started research for developing elements of grade technology for them.

The research was aimed at studying the yield and grain quality of the middle-early spring wheat cultivars Tyumenskaya Yubileynaya and Tyumenocka, depending on the level of mineral nutrition in the Northern forest-steppe of the Tyumen region.

Materials and Methods

The studies were performed in 2016 – 2018 in the Northern forest-steppe of the Tyumen region, at the experimental field of the Northern Trans-Ural State Agricultural University. For instance, the year 2016 was characterized as arid (Selyaninov Hydrothermal Coefficient = 0.84) in terms of water availability, and the years 2017 and 2018 were characterized as wet (Selyaninov Hydrothermal Coefficient = 1.43). The temperature conditions in the studied years were characterized as favorable for the growth and development of spring wheat plants. The soil was leached black soil, heavy-loamy by the particle size distribution, with the humus content of 7.2 %, medium content of phosphorus and nitrogen, high content of potassium, and soil solution reaction of 6.7 (Belkina, 2017d; Vydrin, 2017). The predecessors were annual herbs (pea + oats). The technology was the one generally accepted for the crop in the area (Isupova, 1999). The technology included dump plowing to a depth of 26-28 cm, spring harrowing, embedding mineral fertilizers at a yield of 50 t/ha, as well as cultivation to a depth of 15-17 cm. For control, the option without fertilizers was used. The registered early ripe varieties Tyumenskaya Yubileynaya and Tyumenocka, bred at the Northern Trans-Ural State Agricultural University, were studied. The dose of mineral fertilizers was calculated using the balance method for the planned yield, annually taking into account the supply of nutrients in the arable layer according to B. Yagodin et al. (2003). Doses of mineral fertilizers over the years of experiments on the planned yield: 4 t/ha = N_{35-120} P_{40-160}; 5 t/ha = $N_{119-200}$ P_{44-200}; 6 t/ha = $N_{130-250}$ $P_{100-255}$. The fertilizer introduction rate was calculated using the balance method per planned yield (Kazak, 2016). Sowing was performed using SSFK-7 selection drill in optimal time (the second ten-day period of May). The plot area was 30 m2, that of registration plots — 25 m2, the experiment was repeated four times, the plots were placed randomly. Observations and accounting were performed according to the method of state grade testing for crops (Kazak, 2015).

The amount and quality of gluten were determined according to GOST 27839-2013, by washing it from the dough using mechanized means and by measuring its elastic properties using a gluten deformation measuring device. The ecological plasticity and adaptability were studied by S. A. Eberhart and W.A. Rassel in the presentation of V. A. Zykin (Lihenko, 2007). Harvesting was performed by a Sampo 130 harvester; the data were processed following the statistical method of B. A. Dospekhov (Lihenko, 2018).

Results and Discussion

Mass media and scientific literature frequently mention the effect of global warming. As applicable to crop production in the Tyumen region, it has been weakly expressed this far. As for spring wheat, the

advantage remains with early and mid-early cultivars, although in individual years, the vegetation period was prolonged, which created certain difficulties in harvesting (Loginov, 2016a, Loginov, 2016b; Loginov, 2017a, Loginov, 2017b). In this regard, great importance is attached to studying the duration of the vegetation period depending on the use of mineral fertilizers (Table 1).

Table 1. The duration of the vegetation period of early-ripening wheat cultivars depending on the level of mineral nutrition

Cultivar	Vegetation period, days				Vs. the reference, ±
	2016	2017	2018	average	
reference (without fertilizers)					
Tyumenskaya Yubileynaya	89	84	96	90	-
Tyumenocka	89	84	96	90	-
4 tons of NPK per hectare					
Tyumenskaya Yubileynaya	89	84	96	90	-
Tyumenocka	89	84	96	90	-
5 tons of NPK per hectare					
Tyumenskaya Yubileynaya	91	86	98	92	+2
Tyumenocka	91	86	98	92	+2
6 tons of NPK per hectare					
Tyumenskaya Yubileynaya	91	86	98	92	+2
Tyumenocka	91	86	98	92	+2

Analysis of the data in Table 1 shows that in the reference variant without fertilizers, and in the variant with the use of mineral fertilizers for the planned yield of 4 t/ha, the duration of the vegetation period of the studied wheat cultivars during the years of the research varied from 84 days in 2017 to 96 days in 2018. On average, over the three years of the research, it was 90 days.

With increasing the level of mineral nutrition for the planned yield of 5 and 6 t/ha, the vegetation period of wheat cultivars increased by two days. It should be noted in general that both wheat cultivars in the Northern forest-steppe zone of the Tyumen region ripened by August 20 – 25 in the reference variant (without fertilizers) and the variants with the use of fertilizers for the planned yield of 4, 5, and 6 t/ha. Moreover, in 2016 – 2017, the moisture content in the grain during harvesting was 12.7 – 13.5 %, i.e., it could be used without drying, thus saving the costs. In 2018, the moisture content in the grain was 15.3 – 24.0 %; therefore, the grain was additionally dried in an active ventilation dryer.

Many years' studies (Moiseyeva, 207a; Moiseyeva, 2017b; Tobolova, 2015) determined that spring wheat productivity was closely related to the field germination rate and plant preservation rate by the time of harvesting.

Field germination rate and plant preservation rate by the time of harvesting are monitored genetically, but their manifestations largely depend on the weather conditions and the elements of the technology used. The effect of mineral fertilizers on the germination rate and plant preservation rate by the time of harvesting may be judged by the data in Tables 2 and 3.

Table 2. Field germination rate of wheat cultivars, depending on the level of mineral nutrition

Cultivar	Field germination rate, %				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	87	94	95	92	-	3.29	0.21
Tyumenocka	95	92	92	93	-	-1.29	0.21
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	92	91	96	93	+1	-0.30	13.11
Tyumenocka	84	94	84	87	-6	2.30	13.11
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	93	96	92	94	+2	0.54	0.50
Tyumenocka	83	93	84	87	-6	1.46	0.50
6 tons of NPK per hectare							

Tyumenskaya Yubileynaya	95	92	97	95	+3	-1.50	8.17
Tyumenocka	88	95	88	90	-3	3.50	8.17
$LSD_{0.5}$	1,5	1,8	1,2	-	-		

Note: the seeding norm is 6.2 million germinating grains per hectare

The studied cultivars reacted differently to the level of mineral nutrition. For instance, for cultivar Tyumenskaya Yubileynaya, with increasing the level of mineral nutrition, the field germination rate increased by 1 – 3 %, compared to the reference (92 %), for cultivar Tyumenocka, on the contrary, a decrease by 6 – 3 % in the germination rate was noted on average over the three years.

Table 3. The effect of the level of mineral nutrition on wheat plants preservation rate by the time of harvesting

+	*Plant preservation rate by the time of harvesting, %				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	95	93	93	94	-	0.86	0.10
Tyumenocka	95	93	92	93	-	1.14	0.10
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	91	96	95	94	-	1.27	0.04
Tyumenocka	93	96	95	95	+2	0.73	0.04
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	93	94	92	93	-1	0.64	0.07
Tyumenocka	96	97	93	95	+2	1.36	0.07
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	93	94	94	94	-	0.50	0.17
Tyumenocka	92	95	93	93	-	1.50	0.17
$LSD_{0.5}$	1.3	0.9	0.7	-	-		

**the plant preservation rate by the time of harvesting was calculated from the number of germinated plants*

Due to screening for adaptability, the wheat preservation rate by the time of harvesting in the last decade increased at many nurseries. It was high enough in the experiment with different levels of mineral nutrition and averaged over the years of the study to 93 – 95 %. Compared to the reference, an

increase of 2% was noted in the plant preservation rate for cultivar Tyumenocka in the variants for the planned yield rate of 4 and 5 t/ha. The analyzed indicator of the Tyumenskaya Yubileynaya cultivar was at the level of the reference variant, and in the variant with 5 tons of NPK per hectare, the plant preservation rate decreased by the time of harvesting by 1 %. The obtained results show the high adaptability of the new wheat cultivars to the conditions of the North forest-steppe zone of the Tyumen region.

The leaf area is one of the main physiological parameters that determine the yield rate (Shakhova, 2017; Eremin, 2016a). The maximum leaf area must be formed by the time of the wheat ear formation phase and thereafter it must remain as long as possible. In the conditions of the Tyumen region, after the phase of earing formation, the leaf area of many cultivars reduces due to the withering of the leaves in the lower tiers, and affection by diseases and pest.

Cultivars Tyumenskaya Yubileynaya and Tyumenocka are more resistant to stress factors, compared to many cultivars in the register, and retain the leaf surface in the "working condition" longer. Besides, the leaves of these cultivars have good shape, they are shorter and broader, they hang down less, and shade the lower leaves to a lesser degree. The new wheat cultivars form the well-developed leaf surface every year (Table 4).

Table 4. The effect of mineral nutrition on leaf area formation by wheat cultivars in the Northern forest-steppe of the Tyumen region

Cultivar	Leaves area, thousand m²/ha				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	46.2	44.7	48.0	46.3	-	0.89	0.77
Tyumenocka	47.1	43.4	46.6	45.7	-	1.11	0.77
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	48.7	47.4	51.6	49.2	+2.9	0.42	6.82
Tyumenocka	55.1	46.3	49.2	50.2	+4.5	1.58	6.82
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	46.9	48.8	54.3	50.0	+3.7	1.14	10.82
Tyumenocka	53.5	47.4	52.6	51.1	+5.4	0.86	10.82
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	45.2	49.2	54.9	49.7	+3.4	1.73	0.11
Tyumenocka	50.0	50.1	51.4	50.5	+4.8	0.27	0.11
$LSD_{0.5}$	2.1	1.6	1.9	-	-		

Analysis of the data in Table 4 shows that both cultivars in the reference variant on average over the three years of the study formed the leaves area of 45.7 – 46.3 thousand m2/ha. The obtained results testify to the high natural fertility of the soil in the experimental field of the Northern Trans-Ural State Agricultural University.

In the variants with the introduction of mineral fertilizers for the planned yield rate of 4 and 5 t/ha, the leaves area for cultivar Tyumenskaya Yubileynaya increased by 2.9 – 3.7 thousand m2/ha, for grade Tyumenocka — by 4.5 – 5.4 million m2/ha. The variant for the planned yield rate of 6 t/ha had no advantage over the variant with the introduction of mineral fertilizers for the planned yield rate of 5 t/ha.

The main economic indicator of a wheat cultivar is the yield rate (Eremin, 2016b; Gadimaliyeva, 2018) (Table 5).

Table 5. Yield rate of medium early wheat cultivars, depending on the level of mineral nutrition

Cultivar	Yield rate, t/ha				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	2.94	3.46	3.53	3.31	-	0.75	0.01
Tyumenocka	2.38	2.97	3.44	2.93	-	1.25	0.01
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	3.84	4.32	4.26	4.14	+0.83	0.69	0.02
Tyumenocka	3.34	3.89	4.28	3.83	+0.90	1.31	0.02
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	4.30	4.79	5.12	4.73	+1.42	1.04	0.00
Tyumenocka	4.32	4.76	5.08	4.72	+1.79	0.96	0.00
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	4.41	4.83	5.20	4.81	+1.50	0.92	0.00
Tyumenocka	4.38	4.90	5.31	4.86	+1.93	1.08	0.00
$LSD_{0.5}$	0.26	0.19	0.23	-	-		

In the reference variant, the yield rate of cultivar Tyumenskaya Yubileynaya varied from 2.94 t/ha in 2016 to 3.53 t/ha in 2018, of cultivar Tyumenskaya — from of 2.38 to 3.44 t/ha. On average over the three

years of the research, the yield rate of the former cultivar was 3.31 t/ha, of the latter cultivar — 2.93 t/ha. In the variants with the introduction of mineral fertilizers for the planned yield rate of 4 and 5 t/ha, the obtained yield rate was close to the planned one. The gain to the reference variant amounted to 0.83 – 0.90 t/ha, and 1.42 – 1.79 t/ha, respectively. In the variant with 6 tons of NPK per hectare, the actual yield rate was much lower than the planned one.

In the market conditions, the yield rate of wheat varieties should be accompanied by grain quality (Garkovenko, 2018; Iglovikov, 2016; Lapochkina, 2017; 28. Likhenko, 2015).

Grain quality is a complex indicator, which includes vitreousness, cup weight, gluten amount and quality, etc (Loginov, 2018; Loginov, 2019; Shamanin, 2017; Yakubyshina, 2018). Grain cup weight depends on grain plumpness and uniformity. Grain cup weight determines flour yield after milling; with that, high cup weight ensures a high flour yield (75 % and more).

Grain cup weight is a grading factor, but its formation also depends on the weather conditions and the elements of the technology, including the level of mineral nutrition (Table 6).

Table 6. Cup weight of the grain of wheat cultivars, depending on the level of mineral nutrition

Cultivar	Grain cup weight, g/l				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	760	764	772	765	-	0.49	19.99
Tyumenocka	758	745	778	760	-	1.51	19.99
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	773	766	790	776	+11	0.97	6.27
Tyumenocka	768	754	780	767	+7	1.03	6.27
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	784	753	778	772	+7	1.36	22.58
Tyumenocka	778	762	766	768	+8	0.64	22.58
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	761	744	768	757	-8	1.22	58.50
Tyumenocka	775	758	762	765	+5	0.78	58.50
$LSD_{0.5}$	3	5	2	-	-		

In the reference variant, cultivar Tyumenskaya Yubileynaya formed the cup weight of wheat grain at the level of strong wheat over all the years of the research. The second cultivar, Tyumenocka, on average over the three years of the experiment, matched the requirements for strong wheat in terms of cup weight, but in the context of the years of the research, it twice failed the strong wheat test following the GOST (760 g/l).

In the variants with mineral fertilizers for the planned yield of 4 and 5 t/ha, the cup weight of the grain of the studied wheat cultivars increased by 7 – 11 g/l, compared to the reference. The variant with 6 tons of NPK per hectare by grain cup weight was inferior to the previous variants.

Vitreousness is an indirect indicator of the baking quality of grain. It is closely related to the protein content. This is a grading factor, but it heavily depends on the insolation, the air temperature, the precipitation rate, the precursor, the mineral nutrition, and other factors. The effect of the level of mineral nutrition on the grain vitreousness of medium early wheat cultivars Tyumenskaya Yubileynaya and Tyumenocka can be judged by the data in Table 7.

Table 7. Cup weight of the grain of wheat cultivars, depending on the level of mineral nutrition

Cultivar	Grain vitreousness, %				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	92	57	67	72	-	0.96	1.84
Tyumenocka	90	53	60	67	-	1.04	1.84
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	94	61	70	75	+3	1.16	22.47

Tumenocka	91	72	67	76	+9	0.84	22.47
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	94	60	89	81	+9	1.24	25.79
Tyumenocka	92	69	78	79	+12	0.76	25.79
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	93	61	90	81	+8	1.12	12.15
Tyumenocka	90	62	79	77	+10	0.88	12.15
$LSD_{0.5}$	1.6	1.2	2.1	-	-		

Grain vitreousness was more significantly influenced by the conditions during the year than the level of mineral nutrition. In all variants of the experiment, in both cultivars, it was low (53 – 72 %) in 2017 and high (90 – 94 %) in 2016. On average over the three years of the research, in all variants of the experiment, vitreousness of the studied cultivars was 67 – 81 %, which was in line with the requirements of GOST for strong wheat, while in 2017 the reference of both cultivars had the analyzed indicator below the GOST requirement for strong wheat.

Depending on dosage of 4 and 5 tons of NPK per hectare for the planned yield rate, grain vitreousness of cultivar Tyumenskaya Yubileynaya increased by 3 – 9 %, of cultivar Tyumenocka — by 9 – 12 %, compared to the reference. The variant with the planned yield of 6 t/ha in terms of grain vitreousness had no advantages over the variant with 5 tons of NPK per hectare.

Gluten is one of the main indicators of grain quality, which is taken into account in market price formation. From many years of Siberian agronomic practice of crop production, it is known that only some registered wheat cultivars can consistently accumulate a high percentage of gluten in the grain over the years (33.Kazak, 2019). It should also be noted that the content of gluten and its quality are influenced by technology. The effect of the level of mineral nutrition on gluten amount and quality in the new wheat cultivars may be judged by the data in Tables 8 and 9.

Table 8. The effect of mineral nutrition on the content of gluten in wheat grain

Cultivar	Gluten, %				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	26.8	27.1	27.9	27.2	-	0.36	0.03
Tyumenocka	21.7	24.3	26.7	24.2	-	1.64	0.03
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	39.3	34.9	36.3	36.8	+9.6	1.08	0.33
Tyumenocka	36.9	33.7	33.4	34.6	+10.4	0.92	0.33
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	41.4	32.4	34.0	35.9	+8.7	1.23	0.05
Tyumenocka	38.1	32.7	33.2	34.6	+10.4	0.77	0.05
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	36.7	31.5	32.6	33.6	+6.4	0.98	0.54
Tyumenocka	36.1	30.4	33.5	33.3	+9.1	1.02	0.54
$LSD_{0.5}$	1.6	1.4	1.9	-	-		

Analysis of the data in Table 8 shows that in the reference variant, cultivar Tyumenskaya Yubileynaya in all the years of the research in terms of gluten content exceeded cultivar Tyumenocka by 1.2 – 5.1 %. It should also be noted that cultivar Tyumenskaya Yubileynaya steadily accumulated gluten at the level of 26.8 – 27.9 %.

In the variant with the introduction of mineral fertilizers for the planned yield rate of 4 t/ha, the content of gluten in both cultivars increased by 9.6 – 10.4 %. Over all the years of the research, the studied cultivars in the mentioned variant had the gluten content at the level of strong wheat.

Further increasing the level of mineral nutrition did not result in higher gluten content in the grain, compared to the variant with 4 tons of NPK per hectare.

The baking assessment of wheat cultivars depends not only on the content of gluten in the grain but also on its quality (Table 9).

Table 9. Gluten quality in medium early wheat cultivars, depending on the level of mineral nutrition

Cultivar	Gluten quality, gluten deformation index (GDI) scores				Vs. the reference, ±	Plasticity, bi	Stability, sd2
	2016	2017	2018	average			
reference (without fertilizers)							
Tyumenskaya Yubileynaya	80	70	45	65	-	0.70	57.7
Tyumenocka	77	40	80	66	-	1.30	57.7
4 tons of NPK per hectare							
Tyumenskaya Yubileynaya	86	60	55	67	+2	1.50	12.5
Tyumenocka	87	75	80	81	+15	0.50	12.5
5 tons of NPK per hectare							
Tyumenskaya Yubileynaya	79	80	65	74	+9	0.91	62.8
Tyumenocka	88	70	75	77	+11	1.09	62.8
6 tons of NPK per hectare							
Tyumenskaya Yubileynaya	87	55	67	69	+4	1.06	16.6
Tyumenocka	85	60	60	68	+2	0.94	16.6
$LSD_{0.5}$	2.9	1.7	2.3	-	-		

In 2017 and 2018, cultivar Tyumenskaya Yubileynaya in the reference formed gluten of the first quality group, in 2016 – of the second group. In two years out of three, Tyumenocka was inferior to the first grade.

In the variants with mineral fertilizers for various yield levels, particularly for 4 and 5 t/ha, deterioration of the quality of gluten was noted in both varieties by 2 – 11 GDI scores, although cultivar Tyumenskaya Yubileynaya in all variants of the experiment had gluten of mainly the first quality group.

In any experiment, it is important to know its economic efficiency (Fig. 1).

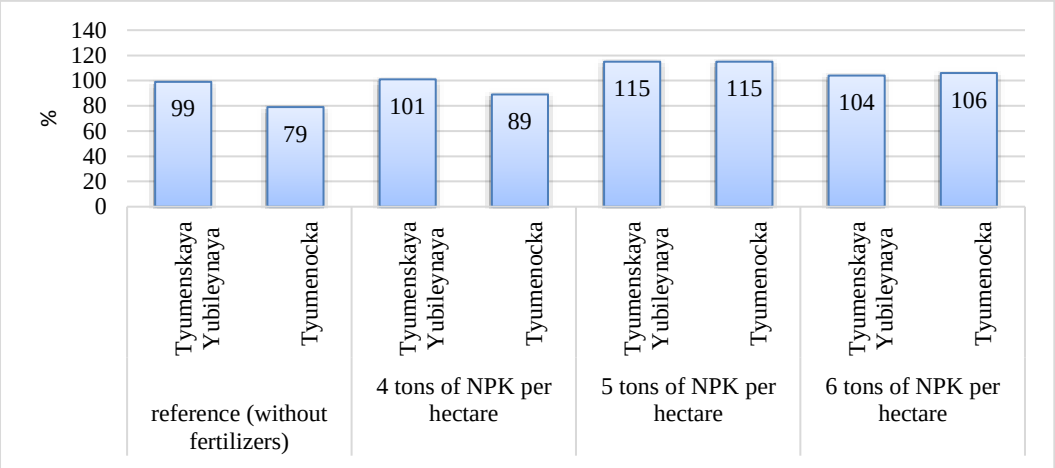

Figure 1. Profitability of spring wheat cultivars, depending on the level of mineral nutrition, 2016 – 2018

According to the economic calculations, the most profitable for cultivating spring wheat in the Tyumen region was the level of mineral nutrition 5 tons of NPK per hectare, the profitability in this variant was 115 %, while in the variants of 4 and 6 t/ha, it was 89 – 106 %, which was by 9 – 26 % lower than in the variant with 5 tons of NPK per hectare.

Conclusion

The length of the vegetation period of the studied wheat cultivars corresponds to the climatic conditions of the forest-steppe zone of the Tyumen region. In the reference variant and the variant with 4 tons of NPK per hectare, it was 90 days, in the variants with 5 and 6 tons of NPK per hectare, it was 92 days.

In the reference variant, the average yield of the Tyumenskaya Yubileynaya cultivar over the three

years was 3.31 t/ha, that of the Tyumenocka cultivar — 2.93 t/ha. It should be noted that the yield of the latter cultivar varied more over the years.

The introduction of mineral fertilizers for the planned yield of 4 t/ha allowed obtaining the yield for the Tyumenskaya Yubileynaya cultivar equal to 4.14 t/ha, which was by 0.83 t/ha more than in the reference variant. The Tyumenocka cultivar yielded 3.83 t/ha, which was by 0.90 t/ha higher than in the reference variant. Further increasing the dosages of mineral fertilizers for obtaining the yields of 5 t/ha allowed obtaining 4.73 – 4.72 t/ha for both cultivars, which was by 0.27 – 0.28 t/ha lower than planned yield. In the variant with 6 tons of NPK per hectare, the yield, compared to the previous variant, increased insignificantly. The Tyumenocka cultivar reacted stronger to increasing the level of mineral nutrition, compared to the Tyumenskaya Yubileynaya cultivar.

The content of gluten in the grain of cultivar Tyumenskaya Yubileynaya in the reference variant was 27.2 %, of the Tyumenocka cultivar — 24.2 %; while it accumulated steadily over the years in the former, it varied a lot in the latter. In the variant with 4 tons of NPK per hectare, an increase in the content of gluten by 9.6 – 10.4 %, respectively, was noted. Further increase in the level of mineral nutrition by 5 and 6 t/ha did not result in increasing the content of gluten in the grain of the new wheat cultivars.

By economic efficiency, the most favorable for spring wheat cultivation in the Tyumen region is the level of mineral fertilization equal to 5 tons of NPK per hectare.

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