Features of cultivation of monoecious drug-free hemp in Western Siberia

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Abstract. The results of research conducted in 2022-2023 on the heavy loamy gray forest soil of the forest-steppe of Western Siberia are presented. The experiments were fixed in the Moshkovsky district of the Novosibirsk region. The purpose of the research was to develop technology elements for the cultivation of monoecious Central Russian hemp in the forest-steppe of the Novosibirsk Ob region. The following varieties were studied: Rodnik (standard), Vera, Nadezhda, and Surskaya. The soil of the experiment plots is heavy loamy gray forest with a humus content of 3.39% at pH 6.43. There was 16 mg/kg of nitrate nitrogen, mobile phosphorus - 14.8, and exchangeable potassium - 12.8 mg/100g of soil. Meteorological conditions during the years of the research differed both in temperature and in the amount of precipitation. During the growing season, 336 mm of precipitation fell in 2022 and only 306 mm in 2023. In terms of heat supply, conditions in 2023 were closer to the average long-term. The experiments were carried out on plots with an accounting area of 9.6 m2, the repetition was fourfold, the placement was randomized. It is shown that in the conditions of the forest-steppe zone of Western Siberia, it is effective to cultivate varieties of Central Russian monoecious hemp on heavy loamy gray forest soil: Rodnik, Vera, Nadezhda, and Surskaya. For hemp cultivation for seeds, a norm of 1.1 million of germinating seeds per 1 hectare should be applied providing a yield of 1.78 t/ha. The fat yield reached 280 kg/ha in the Surskaya variety. The fiber yield was higher with a seeding rate of 3.1 and 3.4 million of germinating seeds per 1 hectare at the level of 0.151 t/ha. With a fiber content of 33.2%. The effectiveness of three-time application of growth regulators Epin-Extra and Zircon, chelated micronutrients Siliplant, Toro Combi, and Turmax on monoecious hemp (seed treatment, during vegetation in the phase of 3-4 real leaves and budding) is shown.

1 Introduction

Common hemp is a multi-use crop and in Western Siberia, to a greater extent, it is grown to produce fiber [1, 2]. Hemp raw materials are used for large-scale production of oil and processed products [3, 4]. Modern varieties of Central Russian monoecious hemp have high plasticity, a complex of economically valuable features [5]. The cultivation of Central Russian drug-free monoecious hemp is a complex and time-consuming process that requires

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specialized agricultural machinery, as well as timely high-quality execution of all technological operations [6]. In Western Siberia, there are climatic and geographical features that allow growing monoecious hemp on different types of soils.

There are works by scientists in the literature on optimizing the elements of hemp production technology to increase its yield and product quality [7-12]. Nevertheless, the proposed technologies are not entirely applicable in the conditions of Western Siberia. In this regard, in 2022-2023, in the Moshkovsky district of the Novosibirsk region, which is part of the northern forest-steppe of the Novosibirsk Ob region, comprehensive studies were conducted to develop elements of the cultivation technology of Central Russian monoecious hemp.

The purpose of our research is to develop technology elements for growing monoecious Central Russian hemp in the forest-steppe of the Novosibirsk Ob region.

2 Objects and methods of research

In the 2022-2023 studies, varieties of monoecious Central Russian hemp were studied: Rodnik (standard), Vera, Nadezhda, and Surskaya. The soil of the experiment plots of the Moshkovsky district of the Novosibirsk region is a heavy loamy gray forest with a humus content of 3.39% with humus pH 6.43. There was 16 mg/kg of nitrate nitrogen, mobile phosphorus - 14.8 mg/kg, and exchangeable potassium - 12.8 mg/100g of soil. Meteorological conditions during the years of research were determined by the arid climate in May and June. During the growing season, 336 mm of precipitation fell in 2022 and only 302 mm in 2023. In terms of heat supply in 2023, they were closer to the long-term average. The experiments were laid on plots with an accounting area of 9.6 m2, the repetition was fourfold, the placement of options was randomized.

Analysis of the agrochemical composition of the soil according to standard methods: easily hydrolyzable nitrogen - according to Kornfield, mobile phosphorus - according to Kirsanov (modified by SIASA according to GOST R 54650-2011), exchangeable potassium - according to Maslova, humus - according to I.V. Tyurin (modified by SIASA according to GOST 26213-2021), exchange pH acidity in salt extract - according to GOST 58594-2019.

During the research, phenological observations, yield structure, and morphological analysis were carried out according to the methodology of the state variety testing of agricultural crops [13]. Indicators of photosynthetic activity of plants in crops were determined: leaf area - by die-cutting method, FSP - according to AA Nichiporovich [14]. Statistical data processing was performed according to B.A. Dospekhov using the SNEDECOR application software package modified by O.D. Sorokin [15].

Hemp was sown in bare fallow. Phosphorus and potash fertilizers were applied for plowing, nitrogen fertilizers were used in spring for pre-sowing cultivation. The total dose of fertilizers was N50 P45 K70

3 Research results and their discussion

In 2022-2023, on the gray forest heavy loamy soil of the Moshkovsky district of the Novosibirsk region, we conducted research on the varietal characteristics of growing monoecious drug-free hemp. Having studied the different seeding rates of drug-free monoecious Central Russian hemp of four varieties: Rodnik (standard), Vera, Nadezhda, and Surskaya. Along with this, the effect of different growth regulators and micronutrients Siliplant 0.01%, Epin-Extra 0.05%, Zircon 0.005%, Toro Combi 0.02%, and Turmax 0.02% on fiber and seed yields was studied. The preparations were used three times: seed treatment

with a working fluid consumption of 10 l/t. During the growing season in the mass phase of 3-4 real leaves and mass budding with a working fluid consumption of 300 l/ha.

It was found that the optimal seeding rate for the standard variety Rodnik was 1.4 mln pcs germinating seeds per 1 hectare with a seed yield of 0.136 kg/ha, the Vera variety also has this norm with a yield of 0.158 kg/ha. The Nadezhda and Surskaya varieties have a norm of 1.1 million pieces with a yield of 0.154 and 0.178 kg/ha, respectively. In all varieties, the values were lower with minimum norms of 0.5-0.8 million pieces and maximum thickened norm of 1.7 million pieces of germinating seeds per 1 hectare. According to the fat yield from 1 hectare, all varieties had the largest amount at a rate of 1.1 million pcs, and with the maximum value in the Surskaya and Nadezhda varieties, respectively, 274 and 280 kg/ha. At 249 kg/ha in the standard Rodnik against the background of rare and thickened sowing (0.5 and 1.7 million pieces), the fat yield per hectare in seeds decreased to 46% (Table 1).

The variance analysis of two-factor experiment determined that the seed yield depended on the genotype by 35%, the seeding rate by 37%, with the interaction of factors of 17%. According to the fat yield of monoecious hemp, the dependence on the genotype was 25%, the seeding rate was 39%, with the interaction of factors 20%.

Table 1. The yield of seeds of varieties of monoecious hemp at different seeding rates and fat yield is the average for 2022-2023.

Option	Seeding rate, million pieces of germinating seeds per 1 ha				
		0.8	1.1	1.4	1.7
	Seed yield kg/ha				
Rodnik (st)		0.096	0.121	0.136	0.124
Vera	0.083	0.123	0.15	0.158	0.141
Nadezhda		0.138	0.154	0.139	0.122
Surskaya		0.124	0.178	0.142	0.12
	Fat yield, kg/ha				
Rodnik (st)	178	226	249	216	210
Vera		243	268	209	189
Nadezhda	182	248	274	218	204
Surskaya	193	259	280	223	208

Note. The results of the variance analysis of the two-factor experiment (4x5), factor A (genotype), B (seeding rate) for yield. LSD 05 for particular differences is 0.026, LSD 05 for A is 0.061, LSD 05 for B and AB is 0.042. The main effects and interactions are: A (genotype) - 34.6%, B (seeding rate) - 36.9%, AB – 17.2%.

For fat yield: LSD 05 of particular differences is 7.6, LSD 0.5 for A is 10.2, LSD 05 for B and AB is 8.9.

A-24.6%, B-39.2%, AB-20.1%

Along with this, the fiber yield was established in varieties of monoecious drug-free Central Russian hemp. The seeding rates of 2.2; 2.5; 2.8; 3.1, and 3.4 million germinating seeds per 1 hectare were studied. It is shown that the Rodnik (standard) variety has a higher fiber yield at a rate of 3.4 million pcs/ha – 0.128 t/ha, the Vera variety 3.1 million pcs/ha - 0.129 t/ha, the Nadezhda variety has the same at rates of 3.1 and 3.4 million pcs/ha at the level of 0.139 t/ha. The maximum yield of fiber from all varieties was in Surskaya, with a seeding rate of 3.4 million pcs/ha, the yield of fiber was 0.151 t/ha. The fiber content was not equal to the Vera variety – 32.6% at a rate of 3.1 million pcs and the Surskaya variety with the same rate - 33.2% (Table 2).

The analysis of variance determined that the fiber yield depended on the genotype by 32%, on the seeding rate by 37%, with the interaction of factors by 23%. The fiber content in the monoecious hemp stock was determined by the variety by 31%, the technology element - by 37%, and the interaction of factors - by 26%.

Table 2. The fiber yield in varieties of monoecious hemp and the fiber content in the stock at different seeding rates. The average for 2022-2023.

Option	The seeding rate is million pieces of germinating seeds per 1 ha				
		2.5	2.8	3.1	3.4
	Fiber yield t/ha				
Rodnik (st)	0.023	0.048	0.086	0.121	0.128
Vera	0.036	0.063	0.094	0.129	0.127
Nadezhda	0.048	0.072	0.098	0.139	0.139
Surskaya	0.039	0.061	0.089	0.136	0.151
	Fiber content, %				
Rodnik (st)	22.3	24.2	28.6	29.8	28.4
Vera	23.8	26.8	29.4	32.6	30.5
Nadezhda	24.5	27.4	28.9	30.1	30.8
Surskaya	25.2	27.8	31.6	33.2	32.4

Note. The results of the variance analysis of the two-factor experiment (4x5), factor A (genotype), B (seeding rate) for yield. LSD 05 for particular differences is 0.013, LSD 05 for A is 0.021, LSD 05 for B and AB is 0.019. The main effects and interactions are: A (genotype) - 31.8%, B (seeding rate) - 36.7%, AB – 22.8%.

For fiber content: LSD 05 of partial differences – 0.18, LSD 0.5 for A - 0.27, LSD 05 for B and AB - 0.24.

A - 31%, B - 37%, AB - 26.2%

Along with this, our researches have studied the fiber yield of monoecious Central Russian hemp, depending on the three-fold use of growth regulators and micronutrients of chelated origin: during pre-sowing seed treatment, in the phase of 3-4 real leaves and in the budding phase. In the Rodnik standard variety, the maximum fiber yield was against the background of the use of Turmax 0.02% and Toro Combi 0.02%, respectively 0.038 and 0.036 t/ha versus 0.022 t/ha in the control, which is 72% higher than the control. In the Vera variety, a 30% excess to control was observed against the background of the Epin-Extra drug 0.005% and in the Nadezhda variety also 28% in the Epin-Extra variant. According to the Surskaya variety, the highest excess of fiber yield to control by 45% was revealed in the variant with Turmax 0.02% and Toro Combi 0.02% about 35%.

In terms of fiber content, all varieties have maximum values against the background of the use of the drug Turmax from 0.002% to 25.1%, in the Rodnik variety to 31.4%, in the Surskaya variety with an excess of 14-23% to control (Table 3).

According to the variance analysis, the fiber yield depended on the genotype by 33%, the growth regulator - 39% and the interaction of factors -19%. In terms of fiber content, the share of the genotype in the stock is 36%, growth regulators - 40%, with the interaction of factors - 22%.

Table 3. The effect of growth regulators on fiber yield and fiber content in monoecious hemp stock. Average data for 2022-2023.

Option	Varieties			
	Rodnik (st)	Vera	Nadezhda	Surskaya
	Fiber yield t/ha			
Control (water)		0.139	0.140	0.137
Siliplant	0.124	0.146	0.148	0.138
Epin-Extra	0.124	0.150	0.149	0.146
Zircon	0.122	0.142	0.140	0.147

Toro Combi	0.136	0.144	0.143	0.150
Turmax	0.138	0.142	0.149	0.154
	Fiber content, %			
1. Control (water)	23.1	23.9	25.1	26.1
2. Siliplant 0,01%	24.6	24.8	25.8	27.6
3. Epin-Extra 0,005%	23.4	23.8	26.2	26.5
4. Zircon 0,005%	23.0	24.6	25.9	26.2
5. Toro Combi 0,02%	24.8	25.1	27.8	28.3
6. Turmax 0,02%	25.1	26.2	28.4	31.4

Note 1. The seeding rate in the experiment is 3.1 million pieces of germinating seeds per hectare. 2. The results of the variance analysis of two-factor experiment (6x4). A (genotype), B (growth regulators). For fiber yield, LSD 05 for partial differences is 0.011, LSD 05 for A is 0.019, LSD 05 for B and AB is 0.016. The main effects and interactions are: A (genotype) - 33.2%, B (growth regulators) - 38.5%, AB – 18.6%.

For fiber content: LSD 05 partial differences – 0.19, LSD 0.5 for A - 0.27, LSD 05 for B and AB - 0.24.

A - 36%, B - 39.8%, AB - 21.8%

We have established the effect of growth regulators: Epin-Extra and Zircon, as well as chelated forms of micronutrients: Siliplant, Thoro Combi, and Turmax on seed yield and fat yield per hectare. It is shown that in all varieties except the Nadezhda variety, the maximum yield of monoecious hemp seeds was noted against the background of the use of the drug Turmax (varieties Rodnik, Vera, and Surskaya) and in the Nadezhda variety with the use of the drug Toro Combi 0.02%. The increase in control (water) was 24% for the Rodnik variety, Vera and Surskaya by 19% and Nadezhda by only 12% (Table 4).

According to the fat yield from one hectare, the maximum values were also observed in the varieties Rodnik, Vera, and Surskaya against the background of the drug Turmax and in Nadezhda with Toro Combi. The drugs increased the fat yield by 14-19%. It was statistically determined that the yield of seeds depended on the genotype by 30%, preparations - 36%, and with the interaction of factors - 25%.

Table 4. Seed yield and fat yield of monoecious hemp depending on the use of growth regulators. Average data for 2022-2023.

Option	Varieties			
	Rodnik (st)	Vera	Nadezhda	Surskaya
	Seed yield, t/ha			
1. Control (water)	0.144	0.142	0.143	0.136
2. Siliplant 0,01%	0.128	0.158	0.149	0.148
3. Epin-Extra 0,005%	0.120	0.150	0.156	0.139
4. Zircon 0,005%	0.110	0.140	0.142	0.135

5. 0,02%	Toro Combi	0.136	0.163	0.163	0.156
6. 0,02%	Turmax	0.142	0.169	0.160	0.162
		Fat yield, kg/ha			
1. (water)	Control	180	205	220	228
2. 0,01%	Siliplant	196	218	236	243
3. 0,005%	Epin-Extra	184	223	222	230
4. 0,005%	Zircon	190	208	225	229
5. 0,02%	Toro Combi	206	219	247	243
6. 0,02%	Turmax	214	227	242	354

Note 1. The seeding rate is 1.4 million pieces of germinating seeds per hectare. 2. The results of the variance analysis of two-factor experiment (4x6). A (genotype), B (growth regulators). For yields, LSD 05 for partial differences is 0.029, LSD 05 for A is 0.064, LSD 05 for B and AB is 0.056. Main effects and interactions: A (genotype) - 29.8%, B (growth regulators) - 35.8%, AB – 24.8%.

By fat output: LSD 05 of particular differences is 9.2, LSD 0.5 for A is 11.6, LSD 05 for B and AB is 10.4.

A - 27.2%, B - 40.6%, AB - 19.3%

4 Conclusion

1. In the conditions of the forest-steppe of Western Siberia on heavy loamy gray forest soil, the effectiveness of cultivating varieties of Central Russian monoecious hemp: Rodnik, Vera, Nadezhda, and Surskaya is shown.
2. The maximum yield of monoecious hemp seeds in all studied varieties was revealed at a seeding rate of 1.4 million pieces of similar seeds per 1 hectare, equal to 0.136 t/ha. The Nadezhda variety had a greater excess to the Rodnik standard - 19%.
3. The yield of fat per hectare was also the highest with a seeding rate of 1.4 million pieces of germinating seeds per 1 hectare, especially for the Surskaya variety - 223 kg/ha. It was statistically shown that the yield of monoecious hemp depended on the genotype by 35% and the seeding rate by 37%, and the fat yield by 25 and 39%, respectively.
4. The fiber yield was higher with a seeding rate of 3.1 million pieces and 3.4 million pieces of germinating seeds per 1 hectare to 0.151 t/ha for the Surskaya variety versus 0.128 t/ha for the Rodnik standard. The fiber content in the stock is higher at a seeding rate of 3.1 million pieces of germinating seeds per 1 hectare to 33.2% in the Surskaya variety and 29.8% in the Rodnik variety.

The variance analysis showed that the yield of hemp fiber was determined by 32% by the genotype and 36% by the seeding rate and fiber content of 31% and 36%, respectively.

5. The use of growth regulators and chelated forms of micronutrients increases fiber yield by 21-38% and fiber content in the stock by 16.25%. It has been statistically shown that the fiber yield depends on the genotype by 33% and the growth regulator by 39%.
6. The yield of monoecious hemp seeds increased against the background of the use of growth regulators and chelated forms of micronutrients by an average of 24-32%, especially with the triple use of Toro Combi 0.02% and Turmax 0.02% (pre-sowing treatment, spraying in the phase of 3-4 real leaves and in the budding phase (up to 37%)).

The fat yield also increased by 19-31% against the background of the use of preparations up to 254 kg/ha in the option with Turmax.
Statistically, it was shown that the seed yield depended on fertilizers by 30% and by 36% on growth regulators.

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