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Influence of cultivation technology on the yield of winter wheat

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Abstract. A comprehensive study has been carried out on the influence of technological methods of growing winter wheat on the process of formation of the above-ground mass of plants in the conditions of the forest-steppe of Ukraine. Crop rotation was carried out with two predecessors: black fallow and spring barley at a seeding rate of 3 and 5 million viable seeds/hectare. Evaluation of the intensity of plant development in the initial period of vegetation (measurement of absolutely dry weight of 100 plants 15 and 30 days after the emergence of full seedlings) was recorded in winter wheat plants in black fallow crops. The largest above-ground mass of the plant was formed 30 days after the emergence of full seedlings. A direct correlation was established between the amount of productive moisture in the soil layer of 0-25 cm and the period of emergence of winter wheat seedlings. The highest level of winter wheat yield was obtained for black fallow 3.46 t/hectare when sown in the second decade of October.

1 Introduction

Winter wheat is the leader among cultivated crops in Ukraine in terms of sown area. About 6-6.5 million hectares are annually allocated for it.

Winter wheat is the most valuable food crop. Wheat grain has a high nutritional value and convenience of 20% in the dietary calories of the population. Wheat is used in cereals, pasta, confectionery and distillery production, alcohol production [1]. Biologically active additives for animal nutrition from wheat waste [2].

Most scientists are studying the transition from traditional costly technologies to resource-saving ones based on minimal tillage using combined units that combine several technological operations in one step [3]. Many researchers pay attention to the impact on the yield of fertilizers and plant diseases [4]. Weather conditions and sowing dates are of great importance [5-6]. In our opinion, observing the correct crop rotation is of no small interest [7] which, unfortunately, is not always given sufficient attention. This leads to the fact that

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there are cases of violation of science-based recommendations for the cultivation of winter crops [8]. Sometimes they are sown after insufficiently studied predecessors.

The emergence of new, more intensive varieties of winter wheat poses a challenge for scientists to improve existing and develop new agrotechnical elements for its cultivation [9].

The purpose of this study was to study the complex influence of several factors: predecessors, weather conditions, sowing dates.

2 Materials and methods

The soil on the experimental field is represented by typical chernozem, slightly washed away. Its agrochemical indicators:

- pH of salt extract was 6.45–7.0;
- the content of humus in the topsoil is 5.5%;
- the content of nitrate nitrogen is 2–3 mg per 100 g of soil;
- the content of mobile phosphorus (according to Chirikov) is 10.2 mg per 100 g of soil;
- the content of exchangeable potassium (according to Surikov) 179 mg per 1 kg of soil.

The dates for sowing soft winter wheat of the first grade were: September 5 and October 15. Wheat seeds were sown with a CH-16 seeder in a continuous way. The seeding depth was 6–7 cm [10-11]. The technology was generally accepted for the forest-steppe zone of Ukraine. The crop was harvested with a Sampo-500 combine. The experiments were carried out in triplicate [12].

The size of the sown area of one plot was 80 m^2. The size of the accounting area was 60 m^2. The plots were arranged sequentially [13]. The background application of mineral fertilizers was carried out immediately before sowing wheat according to the results of an agrochemical analysis of the soil:

- in the field of black steam – N60P45K30 kg/hectare;
- in the field after spring barley – N90P45K45 kg/hectare.

The average long-term norm of atmospheric precipitation in the middle of the first ten days of September (sowing date on September 5) was 371 mm. In the studied years, the amount of precipitation for the harvest of winter wheat was:

- in 2016-2017 less by 38.6%;
- in 2018-2019 less by 35.6%;
- in 2017–2018 г. more on 6.36%.

The temperature regime of the air during the growing season of winter wheat exceeded the values of the average long-term norm:

- in 2016-2017 on 2.3 °C
- in 2017-2018 on 0.9 °C.

The intensity of plant development in the initial period of vegetation determines the level of their adaptability to environmental conditions in the autumn period [14]. To assess the intensity of accumulation of the above-ground mass of winter wheat, the absolute dry mass of 100 plants was measured 15 and 30 days after the emergence of full seedlings [15].

3 Results and discussion

Average for 2016-2018 the largest absolutely dry mass in winter wheat plants was recorded in crops on black fallow (Table 1).

Table 1. Absolutely dry weight (g) of 100 plants of winter wheat (autumn period of 2016-2018)**.**

Sowing dates	**Seeding rate million germi-nating seeds/ hectare**	**The timing of the selection of plant samples after the emergence of full seedlings**							
		after 15 days				**after 30 days**			
		2016	**2017**	**2018**	**mean**	**2016**	**2017**	**2018**	**mean**
Predecessor is black couples									
Septem-ber 5	3	5.3	4.5	4.5	4.8	16.0	15.5	15.3	15.6
	5	5.1	4.3	4.2	4.5	15.5	15.1	15.0	15.2
October 15	3	2.9	2.7	3.1	3.0	8.9	8.8	8.7	8.8
	5	2.6	2.6	2.8	2.7	8.5	8.5	8.5	8.5
Predecessor is spring barley									
Septem-ber 5	3	3.0	2.6	2.8	2.8	7.9	7.3	7.0	7.4
	5	2.8	2.3	2.6	2.6	7.5	6.7	6.6	6.9
October 15	3	2.2	2.5	2.5	2.3	5.3	5.3	5.2	5.3
	5	2.1	2.1	2.3	2.2	5.0	5.1	5.1	5.1

The largest above-ground mass of the plant was formed 30 days after the emergence of full seedlings for all predecessors. Comparison of absolutely dry mass of plants 15 and 30 days after germination showed that winter wheat gave the greatest increase (3 times) when sown after black fallow compared (2.5 times) with sowing after spring barley [16].

The absolutely dry mass of winter wheat plants 15 days after full emergence when sown in the first ten days of September averaged 4.5–4.8 gr for black fallow and 2.6–2.8 gr for spring barley [17]. With late sowing (October 15), the trend remained: 2.7-3.0 gr for black fallow and 2.2-2.3 after spring barley [7].

The relationship between the intensity of the accumulation of aboveground mass by plants and the timing of sowing has been established [18]. For 2016-2018 absolutely dry weight of 100 plants of winter wheat exceeded the weight of plants from crops after spring barley by 53-55% when sowing on September 5 and by 39-40% when sowing 15 October [19]. The difference was: with early sowing (September 5) 33-40%, with late sowing (October 15) 17-27% [20].

The conditions of nutrition and lighting in agrophytocenoses varied depending on the seed sowing rate [21]. In thickened crops (5 million germinating seeds/ hectare), the weight of 100 absolutely dry plants was the smallest, which is explained by the worst growing conditions. As a result, the plants formed fewer shoots and a smaller leaf surface area, compared with lower sowing rates [22].

The processes of accumulation of aboveground mass by plants during the spring-summer vegetation period depend on the reserves of productive moisture in the soil [23]. Agricultural practices had a significant impact on the growth and development of winter wheat. The period of the most intensive accumulation of productive moisture was the time from the phase of stem elongation to earing [24].

Sowings of early terms slowly restored their above-ground mass after overwintering, in contrast to crops with late sowing dates. The absolutely dry weight of 100 plants, when sown on September 5 in black fallow, increased by 3.1 times by the time they were planted. With late sowing (October 15), the increase in absolutely dry weight was only 6 times. A similar relationship was observed when sowing after spring barley [25].

The accumulation of above ground mass by winter wheat plants during the spring-summer period proceeded unevenly. The intensity of growth processes in plants was insignificant after restoration of spring vegetation before stem elongation. An increase in air temperature contributed to a sharp increase in all processes. The maximum intensity of growth processes with the accumulation of overground mass was observed in the period from stem elongation to earing (Table 2).

The results obtained (Table 2) indicate that the largest above-ground mass was formed by winter wheat plants. This is due to the better provision of plants with moisture and light compared to more dense crops. Similar research results were obtained by other researchers [16].

The condition for obtaining friendly seedlings of plants is the presence of productive moisture at the depth of seeding [26]. The average duration of germination with early sowing (September 5) in our experiments was 22 days. With late sowing (October 15), winter wheat seedlings appeared after 15 days [27].

Table 2. Absolutely dry weight (g) of 100 plants of winter wheat, depending on the technological methods of cultivation during the spring-summer growing season 2017-2019.

Sowing dates	Seeding rate million germinating seeds/ hectare	Predecessor is black couples			Predecessor is spring barley		
		restoration of spring vegetation	stem elongation	earing	restoration of spring vegetation	stem elongation	earing
September 5	3	67.5	283.3	857.0	40.0	214.2	854.4
	5	65.7	204.2	555.6	38.1	169.5	559.5
October 15	3	19.2	153.6	627.5	15.5	135.7	630.8
	5	18.3	109.9	425.6	15.0	112.7	409.5

Field germination and the time of emergence of seedlings by years depended on weather conditions (Table 3).

Table 3. Influence of the term and seeding rate on the field germination of winter wheat seeds.

Sowing dates	Seeding rate million germinating seeds/ hectare	Field germination (%)			Sprouting period (days)		
		2017	2018	2019	2017	2018	2019
September 5	3	51.3	60.9	82.4	31	20	16
	5	58.4	76.2	87.8	31	19	15
October 15	3	55.8	64.2	86.9	25	13	9
	5	62.7	84.0	93.6	24	11	8

In 2017, with early sowing (September 5), seedlings appeared after 31 days, when precipitation of 12.5 mm fell. Field germination averaged 54.85%. With late sowing (October 15), seedlings appeared after 24-25 days, and field germination averaged 59.25% [28].

In 2018–2019 favorable weather conditions prevailed. With early sowing (September 5), field germination averaged: at a seeding rate of 3 million viable seeds/ hectare 68.55% (sprouting period 19 days), at a seeding rate of 5 million viable seeds/ hectare 85.1% (sprouting period 15 days).

With late sowing (October 15), field germination averaged: at a seeding rate of 3 million viable seeds/hectare 74.1% (sprouting period 11 days), at a seeding rate of 5 million viable seeds/hectare 90.25% (sprouting period 8 days). It was ensured by better supply of productive moisture during late sowing (October 15) [29].

According to the results of the research, a correlation was established ($Y = -1.71\,x + 46.62$) between the amount of productive moisturex in the soil layer 0-25 cm and the germination period Y of winter wheat (Figure 1).

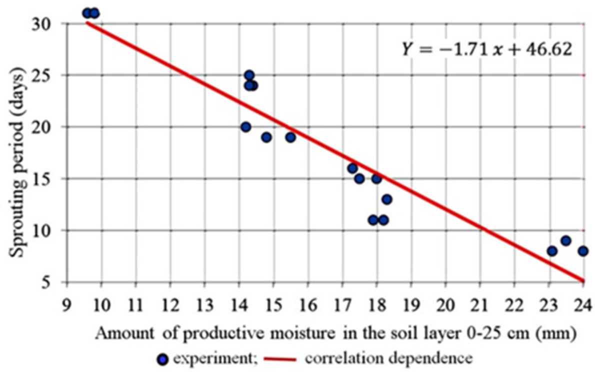

Fig. 1. Dependence of the period of germination of winter wheat on the amount of productive moisture in the soil layer of 0-25 cm.

The main indicator of the effectiveness of technological methods is the grain yield (Table 4).

Table 4. Winter wheat yield (t/ hectare) depending on the seeding rate and predecessor at late sowing (October 15).

Predecessor	Seeding rate million germinating seeds/ hectare	2017	2018	2019	mean
Black couples	5	3.33	3.14	3.91	3.46
	3	3.35	3.04	3.46	3.28
Spring barley	5	1.71	2.58	3.78	2.69
	3	1.69	2.68	3.52	2.63

On average, the highest yield (3.46 t/ hectare) was provided by crops on black fallow at late sowing (October 15) with a seeding rate of 5 million viable seeds/ hectare.

4 Conclusions

A comprehensive study was carried out on the influence of various factors on the yield of winter wheat.

The analysis of the obtained results showed that the predecessor had the greatest influence on the formation and growth of winter wheat. Higher rates of winter wheat were in black fallow crops. Sowing on a black fallow compared with sowing after spring barley, depending on the timing and sowing rates, increased the absolutely dry weight of 100 plants of winter wheat by 17-55%. The yield of winter wheat in the black fallow crop rotation exceeded the yield of winter wheat in the crop rotation after spring barley by an average of 20-22%.

The period of germination of winter wheat directly depends on the amount of productive moisture in the surface soil layer of 0-25 cm. In the conditions of the forest-steppe of Ukraine, the highest provision of soil with productive moisture was observed in mid-October. With late sowing (October 15), seedlings appeared 4-7 days earlier than with early sowing (September 5). Field germination of seeds with a late sowing period was higher by 5% in 2017 and by 16% in 2018-2019. The increase in the absolute dry weight of winter wheat plants in the crop rotation on black fallow twice (from 3 to 6) was achieved only by changing the sowing time.

It has been confirmed that the technological methods used in Ukraine for growing winter wheat make it possible to form a yield of 3.46 t/ hectare.

References

1. M. Orlovsky, T. Tymoshchuk, O. Konopchuk, V. Voitsehivsky, I. Didur, Scientific Horizons **11**, 77-85 (2019)
2. V.P. Netsvetaev, Y.O. Kozelets, A.P. Ashcheulova, O.E. Nerubenko, O.V. Akinshina, Russian Journal of Genetics **56(1),** 1435-1444 (2020)
3. V.V. Blednykh, P.G. Svechnikov, I.P. Troyanovskaya, Procedia Engineering **150**, 1297-1302 (2016)
4. V. Bondar, N. Makarenko, Acta Agriculturae Slovenica **115(1)**, 67-78 (2020)
5. L-H. Lü, S-B. Liang, L-H. Zhang, X-L. Jia, Z-Q. Dong, Y-R. Yao, Acta Agronomica Sinica (China) **42(1)**, 149-156 (2016)
6. Y. Syromyatnikov, I. Troyanovskaya, R. Zagidullin, E. Tikhonov, A. Orekhovskaya, S. Voinash, Acta Technologica Agriculturae **3**, 159-165 (2023)
7. T.A. Dudkina, N.V. Dolgopolova, IOP Conference Series: Earth and Environmental Science **954(1)**, 012025 (2022)
8. I.A. Wolters, E.V. Pismennaya, O.I. Vlasova, V.M. Perederieva, V.I. Faizova, IOP Conference Series: Earth and Environmental Science **624(1),** 012200 (2021)
9. A.G. Stupakov, A.V. Shiryaev, M.A. Kulikova, T.V. Oliva, V.I. Zheltukhina, N.V. Shiryaeva, IOP Conference Series: Earth and Environmental Science **848(1),** 012102 (2021)
10. Z-H. Xin, J-P. Guo, K.-Y. Tan, Chinese Journal of Agrometeorology **39(9)**, 601-610 (2018)
11. V. Likhovidova, N. Kravchenko, E3S Web of Conferences **273**, 01026 (2021)
12. Y. Syromyatnikov, I. Troyanovskaya, S. Voinash, A. Orekhovskaya, V. Sokolova, K. Maksimovich, R. Galimov, S. Lopareva, Journal of Terramechanics **98,** 1-6 (2021)
13. A. Siroshtan, V. Kavunets, O. Derhachov, S. Pykalo, L. Ilchenk, American Journal of Agriculture and Forestry **9(2)**, 76-82 (2021)
14. I.I. Gureev, L.B. Nitchenko, I.A. Prushcik, South of Russia: Ecology, Development **17(1),** 119-127 (2022)
15. A.Y. Kishev, K.Z. Berbekov, Z.S. Shibzukhova, Z-G.S. Shibzukhov, N.I. Mamsirov, E3S Web of Conferences **254,** 02028 (2021)
16. J. Chen, C. Zhao, G. Jones, H. Yang, Z. Li, G. Yang, L. Chen, Y. Wu, Artificial Intelligence in Agriculture **6**, 1-9 (2022)
17. K. Malkanduev, R. Shamurzaev, A. Malkandueva, E3S Web of Conferences **262**, 01013 (2021)
18. B. Tarasenko, V. Drobot, I. Troyanovskaya, A. Orekhovskaya, S. Voinash, V. Sokolova, K. Maksimovich, R. Galimov, S. Lopareva, Journal of Terramechanics **99**, 29-33 (2022)
19. J.K. Jansson, K.S. Hofmockel, Nature Reviews Microbiology **18(1)**, 35-46 (2020)
20. M.M. Moghimi, G. Shamshiri, A. Shabani, A-A. Kamgar-Haghighi, M. Fateh, M.R. Mahmoudi, Irrigation and Drainage **71(2),** 349-364 (2022)

21. S.D. Shepelev, A.M. Plaksin, I.P. Troyanovskaya, M.V. Pyataev, E.N. Kravchenko, Lecture Notes in Mechanical Engineering, 341-350 (2022)
22. A.S. Gimbatov, M.G. Muslimov, A.B. Ismailov, G.A. Alimirzaeva, E.K. Omarova, Research Journal of Pharmaceutical, Biological and Chemical Sciences **7(5),** 1304-1310 (2016)
23. M. Shevnikov, O. Milenko, I. Lotysh, D. Shevnikov, O. Shovkova, American Journal of Agriculture and Forestry **9(4),** 211-218 (2021)
24. A. Gostev, D. Dubovik, N. Masyutenko, L. Nitchenko, V. Reznik, V. Kruglov, R. Davydov, IOP Conference Series: Earth and Environmental Science **390(1)**, 012040 (2019)
25. X-D. Li, Q. Chen, Q. Ge, J. Dai, L. Dai, X. Zou, J. Chen, Agricultural and Forest Meteorology **248**, 518-526 (2018)
26. X. Yang, L. Zheng, Q. Yang, Z. Wang, S. Cul, Y. Shen, Agricultural Systems **166**, 111-123 (2018)
27. K.Yu. Maksimovich, R.Yu. Dudko, E.A. Novikov, Eurasian Entomological Journal **21(3)**, 166-174 (2022)
28. A.N. Kryukov, V.N. Naumkin, N.V. Kotsareva, I.V. Orazaeva, T.S. Morozova, T.P. Shulpekova, IOP Conference Series: Earth and Environmental Science **848(1)**, 012103 (2021)
29. V. Isaychev, N. Andreev, F. Mudarisov, IOP Conference Series: Earth and Environmental Science **937(2),** 022130 (2021)