Advances in Engineering Research, volume 151
International Conference on Smart Solutions for Agriculture (Agro-SMART 2018)

Crop Yields For Various Soil Treatment Variants in the Northern Forest-Steppe of Tyumen Oblast

Rzaeva Valentina
FSBEI HE Northern Trans-Ural SAU
Tyumen, Russia
e-mail: valentina.rzaeva@yandex.ru

Fisunov Nikolay
FSBEI HE Northern Trans-Ural SAU
Tyumen, Russia

Miller Stanislav
FSBEI HE Northern Trans-Ural SAU
Tyumen, Russia

Abstract—The problem of soil treatment is among the most current and the most controversial in agriculture. Mechanical soil treatment is the most common operation in agriculture, which is essential for any crop cultivation. The objective was to assess the efficiency of main soil treatment in crop cultivation. The research has been conducted in the experimental field of the Department of Farming, Northern Trans Ural State Agricultural University in 2008-2016. The soil there is leached chernozem, heavy loamy by its granulometric composition, with morphological attributes which are typical for Western Siberia. The multi-year research has established the efficiency of a differentiated main soil treatment when cultivating crops under a crop rotation. Thus, yield of annual grasses exceeded the control values (moldboard soil treatment) by 1.25 t/ha, that of spring wheat exceeded the controls by 0.24 t/ha (the first grain after seeded fallow) and by 0.21 t/ha (the second grain after seeded fallow). It should be noted, that yield of the spring wheat is higher in the first crop after seeded fallow. The yield of the second spring wheat after seeded fallow is 0.17 t/ha lower than the yield of the first wheat after the seeded fallow in moldboard soil treatment condition (control, 20-22 cm), 0.06 t/ha lower than in non-moldboard cultivation, and 0.20 t/ha lower than in differentiated deep soil treatment. Reduced basic cultivation depth and totally abandoning the basic cultivation lead to reduced yield of the cultivated crops. Increased remoteness from seeded fallow (pea and oat) promoted lower yields.

Keywords—soil treatment; soil treatment depth; yield, crops, spring wheat, annual grasses.

I. INTRODUCTION

The issue of soil treatment was always pertinent through the history of agriculture, and as a result, it has often been being controversial, especially when speaking of the soil treatment depth. There is no common opinion on the depth and time scales of the basic cultivation. Many authors after studying the methods of main soil treatment and their efficiency against weed infestation came to a conclusion that moldboard treatment is much better against weeds than non-moldboard, minimal and zero-till treatments [1-4].

The problem of soil treatment is among the most current and the most controversial in agriculture. Mechanical soil treatment is the most common operation in agriculture and is essential for any crop cultivation [6].

Crop yields largely depend of water-related and physical properties of soils, availability of nutrients to plants, weed infestation, previous crop cultivated in the field, duration of the vegetation period, methods of the main soil treatment.

Research objective: to assess the efficiency of main soil treatment in crop cultivation.

II. SUBJECTS AND METHODS

The research followed an approved method and the experimental design (Table 1) in the experimental field of the Department of Farming, Northern Trans-Ural State Agricultural University in 2008-2016.

The soil is leached chernozem, heavy loamy by its granulometric composition, with morphological attributes which are typical for Western Siberia [6].

Subject of research: batches of crops, leached chernozem.

In the batches of spring wheat, a tank mixture of herbicides was used against monocotyledon and dicotyledon plants: Gepard (0.6 l/ha) + Sekator (125 g/ha) in 2008-2009; Puma Super 100 (0.6 l/ha) + Sekator Turbo (75 ml/ha) in 2010-2013; Aksial (1.0 l/ha) + Derbi (0.06 l/ha) in 2014-2015; Puma Super 100 (0.75 l/ha) + Sekator Turbo (75 ml/ha) in 2016.

Accounting of annual grasses yield for herbage was conducted during the budding of pea.

Accounting of the spring wheat yield was conducted at the stage of full maturity with a SAMPO 500 combine harvester in 2008-2014, and with a TERRION combine harvester in 2015-2016.

The field was plowed after harvesting the forecrop: PN – 4-35 (PON-3-35); loosening for a depth of 20-22 and 28-30 cm – SibIME; PChN-2,3 (2014-2015) and loosening for a

depth of 12-14 and 14-16 cm with a KOS B (UNIA) cultivator.

TABLE I. A SYSTEM OF MAIN SOIL TREATMENT FOR LEACHED CHERNOZEM IN A GRAIN-FALLOW CROP ROTATION, EXPERIMENTAL FIELD OF THE NORTHERN TRANS-URAL STATE AGRICULTURAL UNIVERSITY

Main soil treatment	Crop rotation		
	annual grasses	spring wheat	spring wheat
moldboard	plowing, 20-22	plowing, 28-30	plowing, 20-22
moldboard	plowing, 12-14	plowing, 14-16	plowing, 12-14
non-moldboard	bursting, 20-22	bursting, 28-30	bursting, 20-22
non-moldboard	bursting, 12-14	bursting, 14-16	bursting, 12-14
Differentiated	bursting, 20-22	plowing, 28-30	bursting, 20-22
Differentiated	bursting, 12-14	plowing, 14-16	bursting, 12-14
No-till	Without tillage since 1975.		
	Without tillage since 2008.		

III. RESULTS

Not all the issues in soil treatment have found complete theoretical and practical resolution; this includes even several very pressing issues. The main ones of them are the issues of the method and depth of soil treatment. From the early days of agriculture, there are heated discussions on advantages of moldboard and non-moldboard, shallow and deep treatment methods. These issues are still unresolved. That is why development of optimal and rational systems for soil treatment is a timely problem [9].

The combined system of soil treatment facilitated formation of higher yields in the studied crops in the crop rotation link [10].

During the years of the research (2008-2016), on average, yields of annual grasses herbage varied in a range of 13.0-16.75 t/ha in the cases with the main soil treatment applied and in a range of 8.72-10.76 t/ha in the to-till cases. In the case of no-till since 1975, yield of the annual grasses is 2.04 t/ha lower than in the case of no-till since 2008 (Table 2).

The yield of annual grasses decreased with decreased soil treatment depth, by 2.30 t/ha for the moldboard treatment, by 2.54 t/ha for the non-moldboard treatment and by 2.93 t/ha for the differentiated soil treatment.

During the nine years of research (2008-2016), the highest yield of annual grasses herbage at the value of 16.75 t/ha was obtained with the differentiated soil treatment for 20-22 cm, which is 1.25 t/ha higher than for moldboard treatment (control) and 1.21 t/ha higher than for the non-moldboard treatment.

During the years of research (2008-2016), average yield of spring wheat (the first year after fallow) was 3.04-3.35 t/ha for 28-30 cm treatments; for the soil treatment variants at 14-16 cm it was lower and amounted to 2.70-2.92 t/ha.

TABLE II. YIELD OF CROPS IN THE GRAIN-FALLOW CROP ROTATION, T/HA, 2008-2016, EXPERIMENTAL FIELD OF THE NORTHERN TRANS-URAL STATE AGRICULTURAL UNIVERSITY

Main Soil Treatment	Annual herbs	Spring wheat	
		first	second
1.Moldboard Deep (control)	15.50	3.11	2.94
2.Moldboard shallow	13.20	2.77	2.62
3. Non-moldboard deep	15.54	3.04	2.88
4. Non-moldboard shallow	13.00	2.70	2.56
5. Differen-tiated deep	16.75	3.35	3.15
6. Differen-tiated shallow	13.82	2.92	2.80
7. No-till (No Tillage since 1975.)	8.72	1.99	1.87
8. No-till (No tillage since 2008.)	10.76	2.31	2.15

When comparing the deep soil treatments with the shallow ones, yield of spring wheat is 0.34-0.43 t/ha higher, that is, decreasing the soil treatment depth led to decreased spring wheat yield.

At the no-till-since-1975 patch, the spring wheat yield was 1.12 t/ha lower than the control values; at the no-till-since-2008 patch it was 0.8 t/ha lower, the difference between no-till variants amounted to 0.32 t/ha. Compared to control (moldboard soil treatment), the shallow treatment variants show yields that are 0.19-0.41 t/ha lower.

During the years of research (2008-2016), average yield of the second year spring wheat on 20-22 cm moldboarded soil amounted to 2.94 t/ha; for non-moldboard treatment at 20-22 cm is was 0.66 t/ha lower than the control (moldboard plowing); differentiated soil treatment with alternating plowing and loosening in the crop rotation) showed the results that exceeded the control values by 0.21 t/ha.

The yield of spring wheat decreased with decreased soil treatment depth, by 0.32 t/ha for the moldboard treatment, by 0.32 t/ha for the non-moldboard treatment and by 0.35 t/ha for the differentiated soil treatment. At the patch that was in no-till since 1975, the wheat yield was 1.07 t/ha below the control values; the patch in no-till since 2008 has shown the yield that is 0.79 t/ha lower than the control values.

Compared to the control values, the yield for the 12-14 cm soil treatment variants was 0.32 t/ha lower for the moldboard treatment, 0.38 t/ha lower for the non-moldboard treatment and 0.14 t/ha lower for the differentiated treatment, that is, reduction in the soil treatment depth actually leads to lower yields of the cultivated crops.

Reduced yields when reducing the soil treatment depth and switching to no-till are explained by increased weed infestation of the batches and higher soil density, leading to lower water availability to the plants.

During the years of research, the highest average yield of the second after-fallow spring wheat was 3.15 t/ha; it was obtained with a differentiated soil treatment in the crop rotation (Variant 5 – loosening at 20-22 cm for the annual grasses and the second spring wheat; plowing 28-30 cm for the first wheat).

It should be noted, that yield of the spring wheat is higher in the first crop after seeded fallow.

The yield of the second spring wheat after seeded fallow is 0.17 t/ha lower than the yield of the first wheat after the seeded fallow in moldboard soil treatment condition (control, 20-22 cm), 0.06 t/ha lower than in non-moldboard cultivation, and 0.20 t/ha lower than in differentiated deep soil treatment.

In shallow soil treatment variants, the yield of the second spring wheat was lower than the first spring wheat, by 0.15 t/ha for the moldboard treatment, by 0.14 t/ha for the non-moldboard treatment, by 0.20 t/ha for the differentiated treatment, and by 0.12-0.16 t/ha for the no-till variants.

Reduced yields when reducing the soil treatment depth are explained by a higher soil density and increased weed infestation of the batches, leading to lower water availability to the plants.

IV. CONCLUSION

The yield of spring crops largely depended on the depth of summer and autumn soil treatment, the maximum grain harvest was obtained under traditional soil treatment (3.70 t/ha), while under surface treatment and direct seeding it reduced by 0.34-0.51 t/ha [11].

The research results are supported with referenced research, for instance: from the data obtained by D.S. Gusarov [12], the yield of the first after-fallow spring wheat was higher than that of the second one.

Many scientists share the same opinion that under modern conditions the main type of soil in crop rotation shall be the differentiated one, providing an alternation (combination) of moldboard and non-moldboard methods, as well as that of deep, shallow and surface treatment [13-19].

Currently, there are several soil treatment concepts. Alongside the supporters of the combined systems in crop rotation that includes a rational combination of moldboard, non-moldboard, surface and no-till treatments, there are supporters of systematic application of shallow, surface and even no-till method alone. The supporters of the second point of view justifiably point to advantages of such methods of treatment (savings in fuel and oil costs, high productivity, profitability of production), but often they conceal or deny some negative aspects of these methods. The arguments for such methods are references to experience of other countries or data obtained in various regions of Russia without employing a control variant. At that, features of the Russian agriculture are not taken into account: presence of heavy soils, infestation with weeds, and lack of necessary technological discipline in agricultural enterprises. The fact that application of such soil treatments in crop rotation would necessarily require using pesticides and fertilizers, which reduces the energy content of the resource-saving methods to the level of traditional plowing. All this is an evidence to the fact that improvement of soil treatment systems and methods is still an important problem for Russian agriculture, the problem that may not have a single solution [20].

From analysis of the multi-year yield data for crops under grain-fallow crop rotation along the systems of main soil treatment, it is easy to see the efficiency of the differentiated soil treatment (alternation of plowing and loosening with crop rotation years and fields).

The results of the multi-year research show that reducing the soil treatment depth and abandonment of the main soil treatment lead to reduced yields of the cultivated crops, which is supported by the referenced research: «practical development first and scientific development second, revealed that with increased cultivation depth, the crop yield increases as well» [21-24].

Introduction of resource-saving methods of the main soil treatment often leads to a reduction of yield by 0.15-0.20 t/ha [25].

Thus, the best results were observed for the differentiated main soil treatment when cultivating crops under a grain-fallow crop rotation. The yield of annual grasses under these conditions exceeded the control values (moldboard soil treatment) by 1.25 t/ha, that of spring wheat by 0.24 t/ha (the first grain after seeded fallow) and by 0.21 t/ha (the second grain after seeded fallow).

References

[1] V.G. Bezuglov, V.N. Sheptukhov, R.M. Gafurov, A.V. Dolgikh, Influence of soil treatment and pesticide application onto phytosanitary state of crops, Zemledelie, no. 2, pp. 33-34, 2004.

[2] M.G. Draganskaya, A.T. Kurilenko, Methods of soil treatment and content of impurities in spring crops, Plodorodie, 2005, no. 3, pp. 27-28.

[3] A.V. Zakharenko, Soil treatment and impurities in crops, Moscow: Zemledelie, no. 1, pp. 20-22, 1997.

[4] I. Kühlinga, D. Redozubov, G. Brollb, D. Trautz, Impact of tillage, seedin grate and seeding depth on soil moisture and dry land spring wheat yield in Western Siberia, Soil&TillageResearch, no. 170, 2017, pp. 43-52.

[5] V.I. Kiryushin, A problem of minimizing soil treatment: Development prospects and research objectives, Zemledelie, no. 7, pp. 3-6, 2013.

[6] I.G. Meltsayev, A.F. Sorokin, Environmental justification for increasing productivity of sgricultural systems in Upper Volga region, Ivanovo: Ivanovo State Agricultural Academy, 508 p., 2015.

[7] D.I. Eremin, "The use of modern data about the composition and properties of soil for the development of transport infrastructure of Tyumen", IOP Conference Series: Earth and Environmental Science, 2017, V. 90, Conf. 1. DOI: org/10.1088/1755-1315/90/1/012021.

[8] D.I. Eremin, "Changes in the content and quality of humus in leached chernozems of the Trans-Ural forest-steppe zone under the

impact of their agricultural use," Eurasian soil science, 2016, 5, pp. 538-545. DOI: 10.1134/S1064229316050033

[9] Yu.N. Pleskachov, I.A. Koscheyev, S.S. Kandybin, Influence of soil treatment over productivity of grain crops. Annals of Altai State Agricultural University, no. 1 (99), pp. 23-26, 2013.

[10] I.P. Talanov, M.R. Akhmetzanov, O.I. Makarova, I.I. Yarmiyev, Influence of soil treatment methods and nutrient status on crop productivity in a crop rotation link. Annals of Kazan State Agricultural University, no. 3 (13), pp. 115-11, 20097.

[11] I.S. Byzov, P.A. Postnikov, Resource-saving soil treatment methods in grain-grass crop rotation, Scientific heritage of T.S. Maltsev and modern issues in Russian agriculture, Proceedings of International Scientific and Practical Conference dedicated to 115th anniversary of T.S. Maltsev. 2011, pp. 73-76.

[12] D.S. Gusarov, Efficiency of field grain-fallow crop rotation methods on meadow chernozems of southern forest-steppe of Omsk oblast. Author's abstract of Cand. Sci. (Agriculture), Omsk, 2008, 16 p. (p 14).

[13] Z.B. Borisonik, Is there a need for differentiated treatment, Moscow: Zemledelie, no. 2, pp. 16-18, 1980.

[l4] V.A. Gulidova, Selection of the best soil treatment method, Moscow: Zemledelie, no. 10, pp. 61, 1990.

[15] V.I. Kiryushin, Preserving type of soil treatment, Moscow: Zemledelie, 1996, no. 2, pp. 53-54.

[16] A.V. Zakharenko, Soil treatment and impurities in crops, Moscow: Zemledelie, no. 1, pp. 20-22, 1997.

[17] A.V. Vrazhnov, E.I. Shiyatiy, Optimization of the soil treatment system in Southern Ural, Moscow: Zemledelie, no. 5, pp. 16-17, 2000.

[18] S.K. Mingalev, Resource-saving technology of soil treatment in agricultural systems of the middle Urals, Author's abstract of Doc. Sci (Agriculture) Tyumen, 2004, 32 p.

[19] V.V. Rzayeva, Effect of autumn soil treatment and herbicides on impurities and yield of crops under grain crop rotation in the northern forest-steppe of Tyumen oblast, Author's abstract of Candidate Sci (Agriculture) Tyumen, 2004, 16 p.

[20] G.N. Cherkasov, I.G. Pykhtin, A.V. Gostev, Possibility of applying no-till and surface soil treatment as a main method in various regions, Zemledelie, 2014, no. 5, pp. 13-16.

[21] N.V. Abramov, Refinement of main elements in the agricultural systems of forest-steppe of Western Siberia, Author's abstract of Doc. Sci. (Agriculture), Omsk, 1992, 32 p.

[22] S.K. Mingalev, Resource-saving technology of soil treatment in agricultural systems of the middle Urals,Author's abstract of Doc. Sci. (Agriculture), Tyumen, 2004, 32 p.

[23] V.V. Rzayeva, V.A. Fedotkin, Spring wheat according to the main soil treatment methods in Northern Trans-Ural, Agroprodovolstvennaya politika Rossii, no. 12, p. 47-49, 2016.

[24] V.V. Rzayeva, Effect of method and depth of the main soil treatment type onto yield of spring wheat in northern forest-steppe of Tyumen oblast, Annals of Orenburg State Agricultural University, pp. 21-23, 2017.

[25] V.G. Bakirov, A role of sowing method in increasing the efficiency of resource-saving technologies and yield, Zernovoye Khozyaystvo, 2006, no. 8, pp. 11-12.