Yield of monocrop winter wheat sowing

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It has been studied that the grain yield of different wheat varieties of winter wheat under monocropping depends on fertilizers and the hydrothermal conditions that during the cultivation as well as on different varietal reactions to the forecrop. The introduction of high ratio of N\textsubscript{120}P\textsubscript{90}K\textsubscript{90} mineral fertilizers did not provide a significant increase in the yields for this forecrop. It is proved that a whole range of agrotechnical measures including proper soil cultivation, rational use of fertilizers, timely sowing with optimal seeding rates and crops care influences the amount and stability of wheat yields. It has been proved that winter wheat monocrop cultivation for 80 years, gradually increased their yields provided sowing more productive varieties.

Keywords: winter wheat, yield, mom crop, fertilizers, variety.

INTRODUCTION

Winter wheat is known to be a strategically important agricultural crop for food grain production though it is the most demanding for its forecrops as compared with other crops. It is noted that winter wheat yield reduces significantly under mono-cropping.

According to the Mironovsky Institute of Wheat, winter wheat yield increase in when is 11.3 centner/ha under crop rotation growing compared with mono-cropping (Remeslo and Saiko, 1975). The average yield of winter wheat in the crop rotation of the Institute for 33 years (1970-2002) was 46.5 centner per hectare, while under mono-crop cultivation it was 31.4 centner per hectare (Rusanov and others, 2006).

V.F. Zubenko, V.N. Yakovenko, Ya.Ya. Panasyuk, who studied the field crops productivity under their permanent cultivation in a crop rotation at the Zhytomyr Regional Agricultural Experimental Station, established that winter wheat yield under mono-crop cultivation without fertilizers was 5 centners /ha, while in crop rotation variant it was 15.2 c / ha, under introduction of 20 t / ha of manure and N30 P45 K45 under mono-cropping it was 16.5 c / ha and under crop rotation it was 32.3 c / ha (Zubenko et al., 1971).

M.K. Pavlenko and others report that crop rotations in the farms of the Kagarlytsky district of the Kiev region were mastered 10 years ago. However, the disadvantage of these crop rotations is that winter wheat is not fully provided with quality fore crops: 20% is sown after silage corn and 6% after the stems covered fore crops. From year to year, the proportion of perennial grasses required by the crop rotation schemes is not followed. In their opinion, the elimination of these shortcomings will make it possible to increase the yield of high-yield winter wheat varieties and increase the gross harvest of grain (Pavlenko et al., 1972).

In his report on agriculture crop rotation academician V.D. Pannikov noted that crop rotation should be flexible and this should be taken into account in his project to provide an agri-ecological substantiation of the alternation of crops without radically changing the established crop rotation fields while changing the structure of the sown area in connection with farms.
specialization and the concentration of production. With the intensification of agriculture, the attitude to the estimation of forecrop changes, there arises the possibility of sowing on the forecrops that are considered insufficiently effective at the current level of agriculture development (Pannykov and Myneev, 1987).

V.N. Remeslo, V.F. Sayko argue in arable practices culture, along with the introduction of agricultural products specialization, causes a need to change the structure of sown areas in individual farms. The experiments carried out at the Institute established that it is possible to obtain more food grain provided the repeated wheat crops are sown after wheat with the N60R60K60 application are introduced in crop rotations. They point out that the winter wheat repeated sowing does not negatively affect the yield of the main technical crop - sugar beet, for which it is the best forecrop (Remeslo and Saiko, 1975).

A.G. Doyarenko came to the conclusion that fallow land is a temporary phenomenon, and the future will undoubtedly belong to sown land (Doyarenko, 1963).

Dieter Shpaar, while estimating the value of fallow land as a forecrop, indicates that it is necessary to consider the fact that the yield of the following crop should recoup the costs of two years. In addition, the fallow lands are problematic in the environmental sense due to wind erosion. In many cases, using fallow land does not pay off, according to long-term experiments in the Forest-Steppe of Ukraine show. However, in extreme regions with annual precipitation of less than 350 mm, where only extensive farming is possible, they are, on the contrary, economically advantageous. In crop rotations loaded with grain crops, in recent years winter wheat is often grown after winter wheat. Such crops need additional costs for plant protection products, which pay off only at very high prices for grains. As a rule, in such crop rotations the yield decreases by 8-15% (Shpaar, 2012).

The significant influence of the forecrops on the productivity of winter wheat is indicated by studies (Wang et al., 2010, Zubets, 2004, Roco and Mengel, 2000). They point out that the value of the forecrops varies depending on the soil and climatic conditions of the zone, the level of the arable practices culture, machinery provision, fertilizers, and the organizational capabilities of the economy of the enterprise.

Forecrops are known to leave a different amount of moisture and nutrients available to plants in the soil, predetermine the structural state of the soil, crops weeding. The agronomic value of the forecrops for winter wheat consists in their ability to provide the plant with the necessary moisture for normal growth and development, and, first of all, for obtaining simultaneous shoots, qualitative development of the root system and the surface vegetative mass in autumn. The nutrients store can be replenished through introduction of fertilizers, and weeding can be conducted with modern effective means.

Winter wheat requires moisture from sowing to harvesting, although at different stages of organogenesis plants need various amount of it. The crops requirements for moisture depend on the moisture of the soil and air, temperature, plant condition, and the intensity of solar radiation. Therefore, maintaining a normal water regime of the soil is a priority task, especially in areas of unstable hydration.

Lack of soil moisture in autumn, especially in the upper 10-cm layer, causes a delay in the seeds germination, late non-simultaneous sprouting, the formation of insufficiently developed root system in the surface layer of the soil. Productive moisture supply during winter wheat sowing depend on forecrops. Black fallow land provides 1.5 times bigger moisture supply at the depth of the seeding, than that after peas for grain and 2.5 times more than for silage corn. The same experiments proved that 5 mm of productive moisture in the arable layer of the soil during the sowing season does not provide winter wheat sowing. Plants will not develop normally if the surface layer of the soil (10 cm) contains less than 10 mm of moisture in the first decade of vegetation, and in the plow layer in the second and third decades contains less than 20 mm of it. M.K. Izhik notes that in the Forest-Steppe of Ukraine forecrop influences the quality of winter crop emergence of seedlings mainly due to the moisture content in the sowing soil layer, which depends on the amount of precipitation in the pre-sowing period. The negative impact of perennial grasses and silage corn on winter wheat crop decreases significantly if the amount of precipitation is more than 20 mm 2 decades before the fall. The scientist found out that field emergence of seedlings shoots of winter wheat seeds sown after perennial grasses and grain winter crops were 10-15% lower than for clear and black fallow lads and silage corn (Yzhyk, 1984). A.P. Orlyuk, O.D. Zhuzha, L.O. Usik argue that the best forecrops should be taken for winter
wheat on seed crops to provide optimal conditions for the development of plants from the first stages of their life. The characteristics of water consumption, ripening and harvesting terms, allelopathic relationships and other biological features of the forecrop exert a noticeable influence on these conditions and field emergence of sprouting (Calderini and others, 1995; Calderini and Ortiz-Monasterio, 2003).

In the black fallow land after the perennial legumes for one hay harvest and after peas (data by the Mironovka Institute of Wheat), the best moistening conditions are created during the sowing of winter wheat. A satisfactory water regime for wheat germination is also established after early silage corn (20-25 days before winter crops sowing). Thus, on the average for 1977-1982, the reserves of water available to plants in the soil layer of 0-20 cm were 33 mm on a black fallow land, 28-27 mm after perennial grasses for one hay harvest and peas, 20 mm, after silage corn, and in a meter layer - respectively: 147, 109 and 84 mm. With regard to corn, it should be noted that only its early harvesting (20-25 days) before winter wheat sowing contributes not only to maintaining the available water in the soil, but also makes it possible to replenish its reserves in 0-20 cm surface due to precipitation, although there is lack of moisture in some dry years in the upper layer during the sowing.

Nutrients content in the soil varies significantly under the influence of forecrops and fertilizers. According to the Mironovka Institute of Wheat, during the period when plants entered the winter, the content of mineral nitrogen in the soil reached: on the control (without fertilizers) on the black fallow land - 3.60, after perennial grasses per one grapes - 3.61, after peas - 2, 49, after corn for early silage - 2.36 mg per 100 g of soil (Zhyvotkov, 1989).

M.K. Zalov found out that yield indicators for different forecrops are directly related to the content of nutrients in the soil. After peas, the soil is saturated with a high content of mobile forms of nitrogen, and this advantage was maintained even during the earing, at a depth of 40 cm N0 after pea it was higher (25.1 mg per kg of soil) than after wheat. As a result, pea as a forecrop provides better conditions for the plants growth and development and contributes to the enhancement of the elements of the crop structure (Zalov, 1971).

Significant dependence of winter wheat yield on forecrops is noted by R.L. Ishchenko. On average for 5 years (1972-1976) the yield of wheat for perennial grasses without fertilizers was 43.8 centner / ha, and for silage corn - 26.8 centner / ha (by 17.0 centner / ha less). Fertilizers introduced after perennial grasses did not confirm the predicted influence on the yield increase while promoting its significant growth after silage corn. Thus, on average over the years, when the main fertilizer was applied at a dose of N90P90K90, corn yield increase made 13.5 c / ha, and when this dose was combined with a three-time top dressing with ammonium nitrate - 18.1 c / ha (44.9 centners / ha). The yield of seeds for these forecrops was almost identical and amounted to 79.8-80.9% (Ishchenko, 1979).

As the experimental data of scientific research institutions and the experience of advanced farms show, the variety of the forecrop is of great importance in the effective use of fore crops. Not all varieties react in a similar way on them.

V.V. Shelepov argues that winter wheat grown after black fallow land and pea provided larger quantity of plants per m² before harvesting, the crops contained more grain and had more productive bushiness than wheat plants growing on other forecrops. All these taken together provided different yields. Owing to creation and introduction of new, more intensive varieties (Zaporozhskayaawny, Semi-dwarf 49, Mironovskaya 61, Mironovskaya 27, etc.) and the agricultural machinery improvement, the productivity of winter wheat on black fallow land and peas has increased even more. New varieties, due to their biological characteristics (resistance to weathering and disease, high winter hardiness, etc.), can better use the potential of the best forecrops (Shelepov et al., 2013).

Wheat is the worst predecessor: the yield of wheat sown on wheat is reduced by 40-50%. This is mainly due to a decrease in the seeds field germinating and a greater loss of plants (Wang and others, 2010).

V.P. Kavunets reports that in the experiments conducted at the Mironovka Institute of Wheat, a difference in the reaction of varieties grown on different forecrops to the applied mineral fertilizers was established. Thus, on peas, the application of N0 active substance per hectare at the IV stage of organogenesis in Mironovskaya 808 caused (due to the crops lodging) 3.7 centners / hectare yield decrease, and in the Mirleben, Mironovskaya 62, Polesskaya 87 varieties, the yield increase was noted to range just 0.9-1.3 centners/ha. Mironovskaya 61 and Mironovskaya 27 varieties reacted positively to nitrogen application, the yield increased by 4.7 and 3.4 c / ha. However, the
yield increase was observed in all varieties under silage corn as a forecrop. A significant increase in the yield was reported in four varieties: Mironovskaya 61, Mironovskaya 27, Mirleben and Polesskaya 87 (Kavunets, 1999).

In the scientifically grounded rotation of the Right-Bank Forest-Steppe, winter wheat is placed after single cut perennial grasses, after pea and corn for green fodder and silage, and under applying appropriate fertilizers the yields are not much inferior to black fallow land wheat productivity (Ilchenko, 1993). Peas for grain is the best among the non fallow land forecrops under applying mineral fertilizers to obtain a high yield of intensive type varieties (Roço and Mengel, 2000).

The study aims to analyze the influence of forecrops on winter wheat productivity, depending on the set of agrotechnical measures, soil cultivation, rational use of fertilizers, timely sowing, variety, optimal seeding rates and crop care.

Research relevance. A significant decrease in the number of appropriate forecrops for winter wheat determines the necessity to study the effect of wheat cultivation in monocropping on its productivity.

MATERIALS AND METHODS

The research material was represented with various varieties of the Institute’s selection. Year of the experiment setting up - 1929.

Soil - typical chernozeml. The humus horizon - 38-42 cm. The arable layer of the soil contains 3.85-4.18% of humus, mobile phosphorus (by Truog) – 12.8-18.9 mg and exchangeable potassium (by Maslova) – 9.5- 12.7 mg per 100 g of soil. Hydrolytic acidity range -1.7-2.2 mg equivalent for 100 g of soil, pH - salt – 5.2-6.1.

The accounted area of the plot -100 m², double repetition. Placing the sites in the experience is systematic permanent. Agricultural practices of winter wheat growing is common for the zone conditions.

The yield was harvested by different harvesters considering the standard (14%) grain moisture.

RESULTS

The yield of different varieties of winter wheat grain under monocropping, depending on fertilizer backgrounds, on the average for the research years accounted for 17.8 c / ha (ranged annually 9.7-31.3 c / ha), and under N60P60K60 application - 26.9 c / ha (ranged annually 17.4-40.8 c/ha) (Table 1), which indicates a significant dependence on the hydrothermal conditions during the cultivation as well as different variety reactions to the forecrop.

The introduction of higher ratio of N120P60K60 mineral fertilizers did not provide a significant yields increase for this predecessor. The same pattern was established for the new variety of YubiljarMironovsky.

The experimental data obtained in the department of varietal agrotechnics also do not give reasons to assert that the winter wheat yield on the control variant has significantly decreased under its invariable cultivation for 80 years. According to the research data by Sellez et al., (Selles and others, 2011) yield reduction under winter wheat mono-cropping is not constant. The results of our studies prove that sowing more productive varieties resulted in gradual increase of their yields.

DISCUSSION

Winter wheat has a minimum yield level in the control without fertilizers, which depends significantly on the variety. According to the research by Wageningen University and Research Center [22], the fears that the yield of modern varieties has reached its biological maximum is not confirmed and there is a constant increase in the yields, which indicates that the selection of new varieties still promotes an increase in the crops productivity.

Organic fertilizers application significantly affects wheat growth and productivity. In monoculture, on average, it increases by 15.1-26.5%, depending on the amount of manure. Hans Raj confirms the effectiveness of organic fertilizer application in winter wheat cultivation and notes that the applying manure from the farm is much better than leaves and chopped wheat straw (Hans Raj and Gupta, 1986).

Applying mineral fertilizers is more efficient than manure in increasing yields in monoculture, but the crops productivity is higher only provided the three elements. i.e. nitrogen, phosphorus and potassium are introduced. The yield increase in comparison with the control in the variants with NPK amounts to 34,1-35,2%.
Soft winter wheat productivity under mono-cropping (stationery field of MIW «New experimental field-1929.»)

<table>
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<tr>
<th>Experimental variant</th>
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<td></td>
<td>Ukrainka</td>
<td>Litestsens 17</td>
<td>Entro spermaum 15</td>
<td>Mironovskaya 264</td>
<td>Mironovskaya 808</td>
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<td>Mironovskaya 61</td>
<td>Mironovskaya 65</td>
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<td>Control</td>
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<td>*Manure, 15 t/ha</td>
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<td>*Manure, 30 t/ha</td>
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<td>15.0</td>
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<td>*Manure, 60 t/ha</td>
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CONCLUSION

While focusing on the forecrops in placing winter wheat varieties, it should be remembered that the crop yields amount and stability depend on a whole range of agrotechnical measures: proper soil cultivation, rational use of fertilizers, timely sowing with optimal rates of sowing, crops care, etc.

The material presented in the article and the long-term experimental data obtained in the long-term studies of the department of crops agrotechnics of the Institute on the study of forecrops influence on winter wheat yield indicate that under the current situation in the crop rotation in most farms, due to common application of non-traditional predecessors (corn for grain, sunflower, soybeans), it is possible to re-plant winter wheat crops after wheat, on condition that the crops are provided with higher ratio of mineral nutrition and intensive chemical protection is applied during the vegetation against pests and diseases.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest”.

ACKNOWLEDGEMENT

We would like to express our gratitude to the V.M. RemesloMyronivka Institute of Wheat of National Academy of Agrarian Sciences of Ukraine, for possibility to obtain the scientific data and their analysis, and to the agricultural enterprise “Zemlya Tomylivska” for financial support for publishing the article.

AUTHOR CONTRIBUTIONS

Aleksandr Demidov made a significant contribution to the concept and design of the study, the acquisition of data and their interpretation.

Andrii Siroshtan conducted monitoring of objects and data collection.

Volodymyr Gudzenko performed laboratory tests and participated in the registration of articles.

Serhii Vakhnyi selected samples and participated in writing the first version of the article.

Valerii Khakhula approved the final version of the article before submission for publication. All authors have read and approved the final version.

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