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YIELD OF SUNFLOWER ON BLACK STEPPE SOIL OF UKRAINE

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SUMMARY

The objective of this paper was to estimate the agronomical efficiency of application of antierosive tillage to the black steppe soil as a basis for ecological growing of sunflower. In the conditions of the Ukrainian steppe, water is the major limiting factor of sunflower productivity. Experiments have shown that after antierosive tillage, the black steppe soil accumulates less water reserve than after conventional plowing. However, the difference, which amounted to 25-30 mm, did not decrease the yield of the sunflower hybrid Zaporozhskiy 9. Cultivation of Zaporozhskiy 9 at the row distance of 15 cm in the variant of antierosive tillage increased the yield of sunflower by 0.2-0.3 t/ha as compared with the cultivation at the row distance of 70 cm in the variant of conventional tillage.

Key words: sunflower, primary soil tillage, distance between rows, herbicide

INTRODUCTION

Conventional plowing is the predominant method of primary soil tillage for sunflower in the Ukrainian steppe. It increases sunflower yield, effectively controls weeds and ensures optimum accumulation of reserve soil moisture (Glukhikh, Kaletin, Popov, 1981). However, the plowing does not keep harvest residues on soil surface in conditions of constant winds in the south of Ukraine. This results in the erosion of the black steppe soil of Ukraine.

Each year the erosion destroys 5-7 million hectares of arable land in the world (Kunze, Bernard, 1991). Total loss of land as a result of agricultural and other activities in the course of human history is estimated at about 2 billion hectares. It exceeds by a large margin the total soil fund of the world. In other words, all continents lost only 2 cm of the surface soil layer. However, the nature needs more than 2000 years to re-create that layer (Marin, Tokareva, 1988; Marin, Tokareva, 1989).

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Therefore, a major cause preventing the growth of crop yields is the steady progress of soil erosion. For example, Ukraine annually loses about 2.5 million tons of grain due to soil erosion adition (Novakovskiy, 1985; Dmitrenko, 1995).

Many researches recommend the replacement of conventional plowing by antierosive tillage (Egorin, Bortsova, 1991; Wagner, Leterme, 1993; Kireev, 1995). However, other researches claim that antierosive tillage of the black soil reduces sunflower yield performance in arid periods and increases soil compaction. After antierosive tillage, the soil accumulates less moisture during fall, winner and spring and the number of weeds increases (Masse, 1983; Kamenev, 1989; Kraevskiy, Poluektov, Bogatiryov, 1993; Vogel, 1993).

Therefore, to obtain high yields of sunflower under conditions of antierosive tillage it is necessary to take a non-standard approach to the application of cultural practices.

The purpose of this investigation was:

1. to evaluate the agronomic effect of antierosive tillage (weed incidence, moisture content in the soil, sunflower yield);
2. to create a sunflower agrophytocoenose (ecosystem) ensuring high competitiveness to weeds and high yield level in response to the antierosive tillage of the black soil;
3. to analyze the effect of the conventional plowing and antierosive tillage of the black steppe soil on sunflower growing at the row distance of 15 cm.

MATERIALS AND METHODS

The experiment was conducted at Institute of Oilseed Crops (Zaporozhie, Ukraine). The Institute is situated in the arid zone of southern steppe of Ukraine. The annual precipitation sum is 420 mm, with 215 mm during growing season. The rainfall during June, July and August is often scant or altogether absent.

The soil in the experiment field was the black steppe soil, with the humus content in the layer 0-20 cm of 3.5 % and the pH of the soil solution from 6.8 to 7.0.

After winter wheat harvest, the experimental field was prepared by the method of improved winter plowing combined with soil tillage in the layers. Two methods of primary tillage were applied, conventional plowing and antierosive tillage. The depth of primary tillage was 27-30 cm. The antierosive tillage was accomplished with the agricultural implement PRPV-5-50. Seedbed preparation and sunflower sowing at the depth of 6-8 cm were performed in the spring.

The sunflower hybrid Zaporozhskiy 9 was sown with row spacings of 70 and 15 cm in the variants of conventional plowing and antierosive tillage, respectively. These agrophytocoenoses were grown with and without Treflan application. Treflan was applied before sowing. The sunflower sowing was done in the last third of April, at the depth of 6-8 cm.

The experiment was harvested with a combine harvester "Sampo 500".

Weed incidence, air-drought mass of weeds, soil water regimen and productivity of sunflower were monitored during growing season.

Each variant of the experiment was made in four replicates.

The obtained results were analyzed by MSTAT test, and means were compared by Tukey's multiple comparison test at 5% level.

RESULTS AND DISCUSSION

The method of improved winter plowing performed in the summer-fall period and the antierosive tillage in early spring ensured an effective control of all kinds of weeds by the herbicide. The omission of herbicide application did not increase weed incidence in the variant of antierosive tillage (3.4-3.6 weeds/meter^2) as compared with the conventional plowing when weed counts were done at the stage of flowering (Table 1).

Table 1: Weed incidence and air-dry mass of weeds in sunflower crop

Method of soil tillage	Herbicide application	Row spacing, cm	No. of weeds per m^2 at flowering	Before sunflower harvest	
				No. of weeds per m^2	Air-dry mass of weeds, g/m^2
Conventional plowing (control)	Treflan (control)	70 (control)	3.0	5.0	4.12
		15	3.9	4.1	3.99
	Without Treflan	15	3.6	4.0	3.80
Antierosive tillage (PRPV-5-50)	Treflan	70	3.4	5.1	3.76
		15	3.6	10.1	3.54
	Without Treflan	15	3.8	9.8	3.54

Values followed by the same letter do not differ significantly at the 5% probability level
*=missing value

The harrowing before and after shoot emergence in the variant of row spacing of 15 cm without Treflan application ensured similar levels of weed infestation in the variants of conventional plowing and antierosive tillage: 3.0-3.9 weeds/meter^2 and 3.4-3.8 weeds/meter^2, respectively. This tendency continued till the end of the growing season. Before harvest, the sunflower plots with row spacings of 70 and 15 cm without herbicide application had 5.0-4.0 weeds/meter^2 and the air-dry mass of weeds of 3.80-4.12 g/meter^2 in the variant of plowing and 5.1-4.0 weeds/meter^2 and air-dry mass of 3.54-3.76 g/meter^2 in the variant of antierosive tillage. The sunflower growing at the row spacing of 15 cm without herbicide application did not increase weed incidence either in the variant of conventional plowing or the variant of antierosive tillage.

The weed density from 3.54 to 4.12 g/meter^2 of air-dry mass of weeds did not influence sunflower productivity. The sunflower productivity was determined by the sowing method. The method of sunflower sowing at the row spacing of 15 cm, irrespective of the method of primary tillage, did not change stalk diameter (2.7-2.9

cm), diameter of sunflower head (18.3-18.6 cm) and 1000-seed mass (51.5-52.7 g) as compared with the sunflower agrophytocoenose with the row spacing of 70 cm. However, it changed seeds mass of a sunflower bud. The seed mass of a sunflower head in the agrophytocoenose with the row spacing of 15 cm was 6.9-7.5 g higher than in the agrophytocoenose with the row spacing of 70 cm, in both variants of plowing.

In the variant of conventional plowing, the agrophytocoenose of the hybrid Zaporozhskiy 9 with the row spacing of 15 cm gave the maximum yields of 3.01-3.06 t/ha (Table 2). The row spacing of 70 cm reduced the yields by 0.24-0.28 t/ha. In the variant of antierosive tillage, the productivity of the hybrid Zaporozskiy 9 growing at the row spacing of 70 cm was reduced compared with the row spacing of 15 cm - 2.75 t/ha and 3.04-3.05 t/ha, respectively.

Table 2: Influence of cultivation practices applied on yield of the sunflower hybrid Zaporozhskiy 9

Method of soil tillage	Herbicide application	Row spacing, cm	Sunflower yield, t/ha	Oil content in seed, %
Conventional plowing (control)	Treflan (control)	70 (control)	2.77	51.0
		15	3.01	52.9
	Without Treflan	15	3.06	52.6
Antierosive tillage	Treflan	70	2.75	51.1
		15	3.04	52.5
	Without Treflan	15	3.05	52.7

Values followed by the same letter do not differ significantly at the 5% probability level
*=missing value

In the arid conditions of the southern steppe of Ukraine, the rainfall sum for the growing season is insufficient in many years (49.9-51.1% and sometimes 34.7-37.3% of the annual precipitation sum). The importance of soil moisture increases in years with a dry and hot summer. Soil moisture plays the main role in the water balance of sunflower. Therefore, the yield level of sunflower in an arid summer will be determined by the reserve soil moisture accumulated in the soil during the fall-winter-spring period. Therefore, accumulation of the large amounts of soil moisture during the period fall - early spring and economical consumption of soil moisture during the summer period are of special significance for the formation of high yields of sunflower. The latter is achieved by correct selection of sunflower hybrids or varieties, in conformity with the climatic conditions of the region, the method of primary tillage and the sowing method.

In this experiment, the black steppe soil after the antierosive tillage accumulated less moisture in the soil layer 0-200 cm (25-30 mm) than after the conventional plowing. After the conventional plowing, the black steppe soil accumulated 288 mm of available moisture in the soil layer 0-200 cm during the period fall-spring. After the antierosive tillage, the available moisture was 263 mm. However, the latter moisture reserve in the soil was enough for the formation of similar yield levels of the hybrid Zaporozskiy 9 in the two variants of plowing.

The sunflower agrophytocoenoses in the variants of conventional plowing and antierosive tillage consumed similar amounts of available soil moisture during the growing season - 194.6 mm and 195.3 mm, respectively. The sunflower agrophytocoenoses with the row spacing of 15 cm on both variants of plowing consumed less available moisture - by 34.0 mm -34.7 mm - than the sunflower agrophytocoenoses with the row spacing of 70 cm. It was due to lower evaporation of soil moisture and larger shading in the sunflower agrophytocoenoses with the row spacing of 15 cm.

The agrophytocoenoses with the row spacing of 15 cm had the oil contents in seed higher by 1.4-1.9% than the agrophytocoenoses with the row spacing of 70 cm. The increases in sunflower yield in the ecosystems with the row spacing of 15 cm did not reduce the oil content in seed. Consequently, the hybrid Zaporozhskiy 9 had the oil yields in seeds of 1.43 to 1.45 t/ha with the row spacing of 15 cm.

The complex of cultural practices for weed control applied to the hybrid Zaporozhskiy 9 increased the weed competitiveness of the ecosystem so that similar yields were obtained regardless of plowing method.

The row spacing of 15 cm provides an opportunity to manage the growth and development of sunflower plants (by changing the ratio of generative to vegetative organs) using either method of soil tillage. It also allows to obtain high yields of the hybrid Zaporozhskiy 9 while improving the economy of production by applying antierosive tillage to the black steppe soil of Ukraine.

The hybrid Zaporozhskiy 9 achieved 68.0% to 87.4% of its genetic yield potential in the agrophytocoenoses with the row spacing of 15 cm and 78.6 to 79.1% in the in the agrophytocoenoses with the row spacing of 70 cm. The antierosive tillage prevented excessive expenditure of soil water for and wind erosion without reduction of yield level of the hybrid Zaporozhskiy 9.

CONCLUSIONS

The antierosive tillage (with the agricultural implement PRPV-5-50) did not reduce the yield of the sunflower hybrid Zaporozhskiy 9 grown on the black steppe soil under arid conditions. The hybrid produced maximum yields in the agrophytocoenoses with the row spacing of 15 cm. Row spacing affected sunflower yield and yield components and water use efficiency of sunflower in dependence of the method of soil tillage.

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RENDIMIENTO DE GIRASOL CULTIVADO EN EL SUELO HUMÍFERO DE ESTEPA EN UCRAINA

RESUMEN

El objetivo de este estudio fue evaluar la eficiencia agronómica de aplicación de la labranza antierosiva del humífero de estepa, con el objetivo de lograr el cultivo ecológico de girasol. En las condiciones de la estepa ucraniana, el agua es el principal factor limitativo para el rendimiento de girasol. Los resultados obtenidos mostraron que el humífero de estepa, después de la labranza antierosiva, acumula menor reserva de agua que después de aplicación de la labranza clásica. Pero, la diferencia en cantidad del agua de reserva (25-30 mm) en el suelo, determinada entre las variantes, no disminuyó el rendimiento del híbrido de girasol Zaporozhskiy 9. El cultivo del híbrido Zaporozhskiy 9 con una distancia entre surcos de 15 cm en la variante de la labranza antierosiva, aumentó el rendimiento de girasol para 0.2-0.3 t/ha respecto a la labranza clásica con una distancia entre surcos de 70 cm.

RENDEMENT DU TOURNESOL DANS LE TCHERNOZIOM DES STEPPES D'UKRAINE

RÉSUMÉ

Le but de cet article était d'établir l'efficacité agronomique d'une culture antiérosive du tchernoziom steppique pour une culture écologique du tournesol. Dans les conditions de la steppe ukrainienne, l'eau est le facteur limitatif le plus important pour la productivité du tournesol. Les résultats obtenus ont montré que le tchernoziom steppique travaillé à l'aide de moyens antiérosifs amasse des réserves d'eau inférieures à celles du tchernoziom labouré de manière traditionnelle. Cependant, la différence dans la quantité d'eau de réserve (25-30 mm) n'a pas été un facteur de diminution de rendement de l'hybride de tournesol Zaporozhskiy 9. La culture antiérosive de l'hybride Zaporozhskiy 9 avec des espaces de 15 cm entre les rangs a augmenté le rendement du tournesol de 0.2 à 0.3t/ha en comparaison avec la culture traditionnelle avec des espaces de 70 cm entre les rangs.