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INFLUENCE OF THE ELEMENTS OF SUNFLOWER CULTIVATION TECHNOLOGY ON YIELD IN POST-HARVEST CROPS UNDER IRRIGATION IN THE SOUTH OF UKRAINE

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The article presents the material on the study of sunflower productivity formation in post-harvest crops depending on mineral nutrition under irrigation in the Ssouth of Ukraine. In order to maximize the productivity of sunflower plants in post-harvest crops, it is necessary to develop rational tillage measures, optimal fertilizer doses and an integrated plant protection system.

The main objective of the study is to determine the effectiveness of different tillage measures and nutrition background for growing sunflower in post-harvest crops under different precrops on irrigated lands of the southern Steppe of Ukraine.

Agroclimatic and soil conditions of the irrigated zone of southern Ukraine allow combining the cultivation of rapeseed for seeds with post-harvest sunflower for oilseeds. Winter rapeseed showed higher productivity in the experiments. The yield of its seeds was 32.6 c/ha, which is 11.7 c/ha more than that of spring rapeseed. The optimal conditions for the growth, development and formation of seeds in sunflower plants are formed when it is grown after the winter rapeseed as a precrop. At a later sowing date after harvesting spring rapeseed, sunflower significantly reduces the yield. Soil tillage systems that were studied in the experiment during the cultivation of sunflower as a post-harvest crop, the best technology was the shallow tillage. In these variants, the seed yield is 12.2–27.3 c/ha, which is 1.2–2.8 c/ha more than in direct sowing. The use of nitrogen-phosphorus fertilizers before sowing sunflower in a dose of N90P90 provided the highest seed yield of 15.9–27.3 c/ha. Compared to the unfertilized control variant and the variant with a dose of fertilizer N45P45, the yield decreased by 45.9 and 48.8% and 19.0–27.0%, respectively. Further increase of the fertilizer dose to N135P135 in the experimental conditions did not lead to an increase in the yield of sunflower seeds. In order to increase the index of irrigated arable land utilization, rise the coefficient of vegetation period utilization and gross production of oilseeds, it is advisable to use winter rape as a precursor for post-harvest sunflower crops.

Key words: *sunflower, post-harvest crops, yield, shallow tillage, mineral fertilizers, precursor, winter rapeseed.*

Минкін М.В. Вплив елементів технології вирощування соняшника на урожайність в післяжнивних посівах при зрошенні в умовах Півдня України

У статті викладено матеріал щодо дослідження формування продуктивності соняшника в післяжнивних посівах залежно від мінерального живлення в умовах зрошення півдня України. Для отримання максимальної продуктивності рослин соняшника в післяжнивних посівах необхідно розробити раціональні заходи обробітку ґрунту, оптимальні дози добрив та інтегровану систему захисту рослин.

Основна мета дослідження полягає у встановленні ефективності різних заходів обробітку ґрунту, фону живлення при вирощуванні соняшнику в післяжнивних посівах за різних попередників на зрошуваних землях південного Степу України.

Агро кліматичні й ґрунтові умови зрошуваної зони півдня України дозволяють сполучати вирощування ріпаку на насіння з післяжнивними посівами соняшника на оліє насіння. Вищу продуктивність в умовах проведення дослідів показав озимий ріпак. Урожайність його насіння склала 32,6 ц/га, що більше, порівняно з ярим на 11,7 ц/га. Оптимальні умови для росту, розвитку і формування насіння у рослин соняшника складаються під час вирощування його після попередника озимий ріпак. За більш пізнього строку посіву після збирання ярого ріпаку соняшник істотно зменшує урожай. Системи обробітку ґрунту, які вивчалися в досліді під час вирощування соняшника, післяжнивною культурою, кращою була технологія з мілким обробітком. У цих варіантах урожайність насіння складає 12,2–27,3 ц/га, що більше, порівняно з прямим посівом на 1,2–2,8 ц/га. Застосування *азотно-фосфорних добрив перед посівом соняшника в дозі N90P90 забезпечило саму високу урожайність насіння 15,9–27,3 ц/га. Порівняно з неудобреним контролем і варіантом з дозою добрив N45P45 урожайність зменшилась на 45,9 і 48,8% та 19,0–27,0% відповідно. Подальше збільшення дози добрив до N135P135 в умовах проведення дослідів не приводило до підвищення врожаю насіння соняшника. Із ціллю підвищення індексу використання зрошуваної ріллі, збільшення коефіцієнта використання вегетаційного періоду і валового виробництва оліє насіння доцільно використовувати як попередник для післяжнивних посівів соняшника озимий ріпак.*

Ключові слова: *соняшник, післяжнивні посіви, урожайність, мілка обробка ґрунту, мінеральні добрива, попередник, озимий ріпак.*

Problem statement. Currently, the most marginal crops are oilseeds, among which sunflower is the leading one. Sunflower seeds and processed products are in demand both on the domestic and foreign markets, and Ukraine is one of the world's leading producers in terms of gross harvest of sunflower seeds.

However, the growth in sunflower seed production was mainly due to an increase in sown areas, instead of the introduction of modern cultivation technologies and irrigation, which would have increased productivity per 1 ha of crop rotation. Since the agricultural sector should develop through intensification, the most important task is to increase the yield of crops, in particular sunflower, by introducing irrigation, less energy-intensive and more productive, soil-protective agricultural practices, high-yielding varieties, and hybrids. In this regard, there is a need to study a set of issues related to optimizing the water-physical condition of dark chestnut soil by improving the measures and depth of tillage in the technology of growing sunflower in post-harvest crops under irrigation in the southern Steppe of Ukraine.

In the South of Ukraine, the problem of increasing sunflower productivity under natural moisture is difficult to solve due to insufficient soil moisture and uneven distribution of precipitation. The southern region's specialization in grain, vegetable, and fodder crops limits the possibility of expanding the area under irrigated oilseeds. At the same time, in irrigated crop rotations after winter and some spring crops, 110–140 days of the growing season with a sum of positive temperatures of 1500–24000 C remain unused. In post-harvest crops, after some cabbage crops, it is possible to grow early ripening varieties and hybrids of sunflower with a growing season of 80–90 days. In order to maximize the productivity of sunflower plants in such crops, it is necessary to develop rational tillage practices, optimal fertilizer doses, and an integrated plant protection system.

Analysis of recent research and publications. The analysis of literature sources has shown that sunflower is the main oilseed crop in Ukraine and in the world. Sunflower production is primarily influenced by the yield of hybrids, cultivation technology, logistics of the industry's enterprises and economic mechanisms for setting the market price of finished products. To date, a wealth of experimental material on the favorable impact on plant productivity in specific agro-climatic conditions has been accumulated [1].

Farms in the steppe zone of Ukraine can grow sunflower as a post-harvest crop after harvesting winter rapeseed for green fodder [2].

In Mykolaiv region, the yield of post-harvest sunflower was 14.6 c/ha for 3 years. In Zaporizhzhia district of Zaporizhzhia region, 16.2 c/ha of post-harvest sunflower seeds were obtained. In the US Corn Belt states, sunflower is grown as the second crop after winter wheat, and at the same time, a full-fledged seed crop is obtained [3]. Despite the fact that post-harvest sunflower crops are an important additional reserve for increasing oilseed production, they have not been widely used in southern Ukraine so far, and one of the main reasons that hinder the expansion of such crops is the insufficient study of the elements of agricultural technology for growing sunflower in post-harvest crops [4, 5].

In the frontline, occupied and de-occupied regions of the country, contamination of agricultural land with unexploded ordnance and mines prevails, which poses a deadly threat to Ukrainian farmers during field work. In the southern region of Ukraine, where high crop yields were achieved through irrigated reclamation, damaged irrigation infrastructure needs to be replaced and repaired [6]. This significantly limits the increase in the area under such crops as sunflower. That is why the most effective way for farms of various forms of ownership in the post-war economic conditions to increase the gross harvest of sunflower seeds is to create and accelerate the introduction of new high-performance elements of sunflower cultivation technology with high agro-ecological adaptability to the natural and climatic conditions of the South of Ukraine.

Task statement. The main objective of the study is to determine the effectiveness of various tillage measures and nutrition background for growing sunflower in post-harvest crops under different precrops on irrigated lands of the southern Steppe of Ukraine.

The goal was achieved by solving the following tasks:

– analytical review of literature sources and information resources on the peculiarities of sunflower cultivation technology in post-harvest crops on irrigated lands of the southern Steppe of Ukraine;

– studying changes in agrophysical properties and water regime under different soil tillage practices;

– determination of sunflower yields depending on tillage practices and nutrition background under different precrops.

To study these issues on dark chestnut medium loamy soils, a field experiment was conducted according to the following scheme:

factor A – precrop – winter and spring rapeseed for seed;

factor B – tillage and sowing system, which includes:

1 – tillage with a disk harrow + cultivation with KPS-4 to a depth of 4–5 cm + sowing with a SPCH-6 seeder with a row spacing of 70 cm.

2 – surface tillage with a seeder-cultivator SZS – 2.1 with simultaneous sowing to a depth of 4–5 cm with a row spacing of 70 cm.

To clarify the sunflower nutrition regimen, we studied the doses of mineral fertilizers (factor C): no fertilizer; N45P45, N90P90, and N135P135.

The experiment was laid out by the split-plot method in quadruplicate, with the area of the sown plots being 240 m^2 and the area of the control plots being 52 m^2. The precrops in the experiment are winter rapeseed of the variety Kvynta and spring rapeseed of the variety Mazhor.

The seeds of winter and spring rapeseed were harvested in two ways, mowed into swaths at 35% grain moisture and picked up when the grain dried to 12–15%. The seed yield of winter rapeseed was 32.6 and the seed yield of spring rapeseed – 20.9 c/ha.

Sowing of post-harvest sunflower hybrid Kharkivskyi-49 was carried out after winter rapeseed in the first decade of July, and after spring rapeseed – in the second decade of July. Before sowing, mineral fertilizers were applied according to the experimental scheme. The sowing was accompanied by the application of Prometryn herbicide (4 kg/ha of the product) to the soil surface and irrigation at a rate of 300 m^3/ha. During the growing season, the irrigation regime was differentiated. The plant density before harvesting in all variants of the experiment was 60 thousand/ha. Harvesting was carried out by the method of continuous harvesting with a combine harvester "Sampo500" after the winter rapeseed precrop in the third decade of October, and after the spring rapeseed in the second decade of November.

Summary of the main research material. The results of the research allow us to identify the effect of various agrotechnical factors (pre-crop, tillage, mineral fertilizers) and their interaction on the accumulation of dry biomass by sunflower plants during the growing season. At the beginning of the growing season, from germination to 2–3 pairs of true leaves, the difference in the accumulation of dry matter by plants in the experimental variants was insignificant, and then significant differences were observed (Table 1).

Table 1

Dynamics of dry matter accumulation by sunflower plants, c/ha

Precrop	**The system of soil cultivation and sowing**	**Nutrition background**			
		without fertilizers	**N45P45**	**N90P90**	**N135P135**
2–3 pairs of true leaves					
Winter rapeseed	Мілка disking + cultivation + sowing SPC-6	1,0	1,1	1,4	1,2
	direct sowing with SZS-2.1	1,0	1,1	1,3	1,1
Spring rapeseed	Мілка disking + cultivation + sowing SPC-6	0,5	0,6	0,7	0,7
	direct sowing with SZS-2.1	0,5	0,6	0,7	0,8
Flowering					
Winter rapeseed	Мілка disking + cultivation + sowing SPC-6	32,9	57,2	84,2	70,3
	direct sowing with SZS-2.11	31,5	45,9	77,0	60,7
Spring rapeseed	Мілка disking + cultivation + sowing SPC-6	24,7	39,2	60,1	57,7
	direct sowing with SZS-2.1	23,6	34,7	58,1	46,9
Achievements					
Winter rapeseed	Мілка disking + cultivation + sowing SPC-6	43,4	74,9	102,9	89,4
	direct sowing with SZS-2.1	40,1	59,5	87,4	75,1
Spring rapeseed	Мілка disking + cultivation + sowing SPC-6	30,2	47,7	71,2	69,4
	direct sowing with SZS-2.1	29,1	42,4	66,2	56,6

During the period of flowering-ripening of sunflower seeds, the positive effect of shallow tillage and doses of mineral fertilizers on the activity of the production process is visible. By the end of the growing season, plants in the variants with shallow tillage accumulated dry matter by 16% more than in the variant with direct sowing after winter rapeseed as a precrop and by 11% more than after spring rapeseed as a precrop. Fertilizers had a significant impact on the accumulation of dry matter. The dose of N45P45 increased this indicator under conditions of shallow tillage after winter rapeseed by 72%, and after spring rapeseed – by 57%, N90P90 after winter rapeseed by 137%, after spring rapeseed – by 135% and N135P135 by 106 and 129%, respectively. The effectiveness of mineral fertilizers decreases with direct sowing of sunflower.

The most favorable conditions for the accumulation of dry biomass of post-harvest sunflower were observed in the experiment when growing it after winter rapeseed on shallow tillage with N90P90 mineral nutrition. The yield of sunflower seeds varied widely under the influence of the precrop, tillage and doses of mineral fertilizers (Table 2).

Table 2

Sunflower yield in post-harvest crops depending on precrops, tillage and nutrition background, c/ha

Precrop	Soil cultivation system, sowing	Nutrition background			
		without fertilizers	$N_{45}P_{45}$	$N_{90}P_{90}$	$N_{135}P_{135}$
Winter rapeseed	Міл disking + cultivation + sowing SPC-6	18,7	22,6	27,3	25,4
	direct sowing with SZS-2.1	16,5	20,5	24,5	22,9
Spring rapeseed	Міл disking + cultivation + sowing SPC-6	12,2	14,3	18,2	18,4
	Direct sowing with SZS-2.1	11,0	13,2	15,9	15,8

NIR 0.5 (c/ha):
– for precrops from 0.35 to 0.9;
– for soil cultivation from 0.35 to 0.9;
– for doses of mineral fertilizers from 0.5 to 1.25;
– for the interaction of factors from 1.76 to 4.2.

The analysis of the data showed that sunflower yield decreases when sown at a later date due to the precrop. The yield reduction is significant and amounts to 6.1–9.1 c/ha. The increase in sunflower yield under the winter rapeseed as a pre-crop is due to better solar energy supply to the plants, which contributed to the increase in productivity. The yield of sunflower in variants with shallow tillage was 2.1–2 c/ha higher compared to surface tillage after winter rape and 1.1–2.6 c/ha higher after spring rape.

Fertilizer application on sunflower crops was effective. The increase in oilseed yields from mineral fertilizers was significant and amounted to 2.1–8.6 c/ha. The use of mineral fertilizers in a dose of N45P45 increased the yield by 3.9–4.0 c/ha in the winter rapeseed precrop and by 2.1–2.2 c/ha in spring rapeseed. When increasing the dose of mineral fertilizers to N90P90, the yield increased by 8.0–8.6 c/ha (45.9–48.8%) compared to the unfertilized variant and by 4.0–4.7 c/ha (19–27%) compared to the dose of N45P45 on the winter rapeseed precrop. After spring rapeseed, increasing the dose of mineral fertilizers to N90P90 provided a yield increase of 4.9–6.0 c/ha (44–49%) compared to the control and 2.7–3.9 c/ha (20–27%) compared to the dose of N45P45.

A further increase in doses of mineral fertilizers was not accompanied by an increase in yield. On average, the maximum yield in the experiment of 27.3 c/ha was obtained in the variant with shallow tillage, when fertilizing at a dose of N90P90 with winter rape as a precrop. A more objective assessment of the study of agrotechnical measures of sunflower cultivation is given by determining the yield of oil per hectare of sowing. These indicators were highest during sunflower cultivation with winter rapeseed as a pre-crop, shallow tillage and a dose of mineral fertilizers N90P90 (Table 3).

On average, over the years of research, the oil yield per hectare was 9.5 c/ha. Improvement of crop cultivation technologies should be aimed at improving its quality. The oil content of sunflower seeds is one of the quality indicators. The most objective assessment of the agrotechnical factors of sunflower cultivation in post-harvest crops is given by determining the oil yield per 1 ha of crops. The calculation data of Table 3 show that the highest oil yield in the experiment is provided in those variants where the highest crop yield was observed.

Table 3

Influence of the elements of sunflower cultivation technology in post-harvest crops on oil yield per hectare

Precrop	Soil cultivation system, sowing	Nutrition background			
		without fertilizers	$N_{45}P_{45}$	$N_{90}P_{90}$	$N_{135}P_{135}$
Winter rapeseed	Disking + cultivation + sowing SPC-6	6,5	7,9	9,5	8,6
	Direct sowing with SZS-2.1	5,7	7,1	8,5	7,9
Spring rapeseed	Disking + cultivation + sowing SPC-6	3,8	4,4	5,5	5,5
	Direct sowing with SZS-2.1	3,4	4,0	4,8	4,7

Depending on soil tillage and nutrition background, the largest amount of oil was collected from 1 ha in plots with a winter rapeseed precrop of 5.7–8.6 c. Compared to this pre-crop, when growing sunflower after spring rapeseed, 1.9–3.1 c of oil was harvested per 1 ha. The oil content of sunflower seeds under the influence of the tillage systems studied in the experiment changed slightly. However, the oil yield was still higher in the variants where shallow tillage was performed by 0.4–1.0 c/ha. Mineral fertilizers had a significant impact on the oil yield per 1 ha of sunflower crops. The largest amount of oil, regardless of the pre-crop and soil tillage, was harvested from 1 ha where a dose of N90P90 fertilizer was applied – 5.5–9.5 c/ha, and the smallest on unfertilized variants – 3.4–6.5 c/ha.

Thus, the irrigated hectare achieves the highest productivity, judging by the amount of oil harvested (9.5 c) under the conditions of complex action of the precrop – winter rapeseed, shallow tillage and mineral fertilizers at a dose of N90P90.

Conclusions. As a result of the conducted research, the effect and interaction of various agrotechnical factors on sunflower productivity were revealed.

Agro-climatic and soil conditions of the irrigated zone of southern Ukraine allow combining the cultivation of rapeseed for seeds with post-harvest sunflower for oilseeds. Winter rapeseed showed higher productivity in the experiments. The yield of its seeds was 32.6 c/ha, which is 11.7 c/ha more than that of spring rapeseed. The optimal conditions for the growth, development and formation of seeds in sunflower plants are formed when it is grown after the winter rapeseed as a precrop. At a later sowing date after harvesting spring rapeseed, sunflower significantly reduces the yield. Soil tillage systems that were studied in the experiment during the cultivation of sunflower as a post-harvest crop, the best technology was the shallow tillage. In these variants, the seed yield is 12.2–27.3 c/ha, which is 1.2–2.8 c/ha more than in direct sowing. The use of nitrogen-phosphorus fertilizers before sowing sunflower in a dose of N90P90 provided the highest seed yield of 15.9–27.3 c/ha. Compared to the unfertilized control and the variant with a dose of fertilizer N45P45, the yield decreased by 45.9 and 48.8% and 19.0–27.0%, respectively. Further increase of the fertilizer dose to N135P135 in the experimental conditions did not lead to an increase in the yield of sunflower seeds. In order to increase the index of irrigated arable land utilization, increase the coefficient of vegetation period utilization and gross production of oilseeds, it is advisable to use winter rapeseed as a precrop for post-harvest sunflower crops.

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MODERN MEASURES OF CONTROLLING ROOT AND SPROUT WEEDS IN GRAPE AGROPHYTOCENOSES

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In modern economic conditions, scientists search for new technological measures for controlling the number of weeds, especially perennial ones, which would be highly effective and low-cost. The purpose of the research is to objectively analyze the effectiveness of technological measures for controlling the development of pink and gray thistle among industrial grape plantations taking into account their characteristics and modern control measures. The most common root and sprout weeds in agrophytocenoses of industrial grape plantations in the south of Ukraine are pink and gray thistles.

The initial infestation of vineyards by pink and gray thistles occurs due to seeds, and subsequently the weeds spread extremely rapidly due to the buds formed on horizontal roots. Despite the biological features of growth and development of pink and gray thistles, the structure of their root system, they often create a monospecies community, from which all other species of weed synusia are displaced, and compete quite successfully with grape bushes and many types of weed phytocoenosis for moisture and nutrients.

Registration of the number and development of weeds at the end of the stage of grape shoot growth in the areas with fallow land showed that the frequency of spread of pink and gray thistle plants, as part of different biological and cenotic communities, reached 53.1–57.4% with an