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OPTIMIZATION OF MEASURES TO INCREASE DISEASE RESISTANCE OF POTATO VARIETIES AS A FACTOR OF REDUCING ENVIRONMENTAL POLLUTION

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ABSTRACT

Potato varieties differed in their resistance to disease. The highest resistance to Rhizoctonia violaceae and Common scab was noted in the variety Granada. The affection of tubers of this variety by Rhizoctonia violaceae did not exceed 1.3%; the affection by Common scab did not exceed 1.8%. The higher affection of potato tubers by Rhizoctonia violaceae and Common scab was noted in the early-ripening variety Laperla and did not exceed 2.2 and 2.9%. The improvement of the agro background of cultivation provided a slight reduction in tuber affection – 0.2-0.3%, respectively. The variety Memphis was characterized by lower resistance to Rhizoctonia violaceae and Common scab compared to the variety Granada, but its resistance was higher compared to the variety Laperla. The affection of potato tubers by Rhizoctonia violaceae and Common scab in this variety did not exceed 1.8 and 2.8%. The affection of plants by viral diseases, providing the annual removal of diseased plants, depended primarily on the conditions of the year of research and varietal characteristics and varied from 0.5% in the variety Granada to 0.9% in the variety Memphis, while it did not exceed 0.7% in the variety Laperla. The conducted analysis of the influence of factors on disease affection indicated a significant share of the impact of genotype resistance – from 92.5 to 96.0%, as well as of the fraction of planting material – from 3.7 to 7.0%. The influence of other factors and their interaction was not significant. Therefore, the introduction of disease-resistant varieties into production and the use of the optimal fraction of planting material will reduce the pesticide load on the environment by reducing the volume of their use.

Key words: potato, diseases, stability.

INTRODUCTION

At the current stage of the development of global agricultural production, when its further intensification is taking place, such requirements as high and stable yield over the years, resistance to unfavourable growing conditions, diseases and pests, adaptability to mechanized cultivation, as well as high product quality are placed on the varieties. The variety, which is characterized by high yield potential in combination with reliable genetic protection of the crop against unfavourable environmental conditions, is the main factor in obtaining consistently high yields of potatoes (Kononuchenko et al., 2002; Biliavska et al., 2021; Mostovenko et al., 2022; Branitskyi et al., 2022).

Taking into account that potatoes in Ukraine are traditionally considered "second bread", the use of high-quality planting material is the main prerequisite for highly productive potato growing. The share of seed material in crop growth is 25-30%, while it is more than 50% in unfavorable growing conditions. This is due to the fact that potatoes, which are propagated by tubers, gradually lose their seed qualities due to the accumulation of pathogens of various diseases in them (Vermenko et al., 2002).
Diseased plants have low viability, which causes a decrease in yield. Therefore, the main measure in obtaining high and stable yields of potatoes is the use of high-quality seed material (Bondarchuk, 2006).

MATERIALS AND METHODS

The research on the study of potato varieties was carried out at the farm "Olvia-S" in the village of Sopyn, Vinnytsia district, Vinnytsia region (Ukraine). The farm is located in the North-Eastern part of the Vinnytsia region.
The research was conducted during 2019-2021. The soil cover of the research area is represented by deep low-humus medium-loamy black soils. The basic seed potatoes were used for the research. Based on the working hypothesis and research objectives, we developed a three-factor experiment with four repetitions.
The air temperature during the growing season in 2019 was 17.1°C, which was by 0.8°C higher than the annual average data. In 2020 and 2021 the air temperature during the growing season was 16.4 and 16.5°C, which was as close as possible to the annual average indicators (Table 1).

Table 1. Characteristics of hydrothermal conditions during the research period

Month	Average monthly air temperature, °C				Amount of precipitation, mm			
	2019	2020	2021	Annual	2019	2020	2021	Annual average
April	9.3	9.2	9.3	9.1	37.8	32	26.8	48
May	15.4	11.7	13.7	14.9	144	136	116	54
June	21.6	20.2	18.9	18.1	88	68	98	83
July	19.0	20.3	19.5	20.2	38	30	54	91
August	20.2	20.4	21.0	19.4	9.2	28	28	69
In total, during the growing season	17.1	16.4	16.5	16.3	317	294	323	345

Regarding the amount of precipitation by month, there is a certain difference between the research years and the annual average data during the growing season. The largest amount of precipitation during the growing season (323 mm) was recorded in 2021, which was by 22 mm less than the annual average data, while it was by 6.0 mm and 29 mm more than the amount of precipitation in 2019 and 2020.

The air temperature during the years of field research shows that during 2019 there is an increase in the temperature regime compared to annual data. The conditions of 2021 turned out to be more favorable both in terms of moisture supply and temperature regime, which was reflected in the processes of growth and development of potatoes.

The basic seed potatoes were used for the research.

Based on the working hypothesis and research objectives, we developed a three-factor experiment with four repetitions.

- The area of the elementary plot is 38.5 m^2. Repetition is four times.
- Factor A – varieties: Laperla – early, Granada – mid-early, Memphis – mid-ripening.
- Factor B – the nutrition background and the method of applying mineral fertilizers. 40 t/ha of semi-rotted manure was applied under the predecessor (winter wheat). Mineral fertilizers such as Potassium magnesium ($K_{28}Mg_8S_{15}$) and Superphosphate (P_{30}) were applied for the main cultivation of potatoes. The complex mineral fertilizer Azofoska ($N_{15}P_{15}K_{15}$) was applied locally during planting or in pre-sowing cultivation.

- Factor C – fraction or mass of planting tubers: < 28 mm or 25-50 g; 28-60 mm (28-55 mm) or 51-80 g; > 60 (55) mm or 81-100 g. According to the experiment options in the varieties Laperla, Granada and Memphis, the costs of planting material on average were: 1) <28 mm or when planting tubers weighing 25-50 g – 2-2.15 t/ha; 2) 28-60 mm (28-55 mm) or when planting tubers weighing 51-80 g – 3.6-3.75 t/ha; 3) > 60 mm (55 mm) or when planting tubers weighing 81-100 g – 5.4-5.55 t/ha.

The field experiments were planned and carried out taking into account the requirements of the methodology of the experimental case [2, 3] and the methodological manual "Methodical recommendations for conducting research with potatoes" [2].

RESULTS AND DISCUSSION

During the period of research, a comparative assessment of disease affection of potato tubers was carried out, which mainly depended on the variety resistance to pathogens and the hydrothermal regime (Table 2).

Table 2. Disease affection and yield of potato varieties depending on fertilizer, fraction of planting tubers and varietal characteristics, 2019-2021

Fertilizer (factor B)	Fraction of planting tubers, mm (factor C)	Disease affection of tubers, %		Aukuba-mosaic	Yield, t/ha
		Rhizoctonia violaceae	Common scab		
Variety Laperla					
Without fertilizers (control)	1	2.2	2.9	0.7	19.5
	2	2.2	2.9	0.7	20.5
	3	2.1	2.8	0.7	21.4
40 t/ha of semi-rotted manure under the predecessor + $K_{56}Mg_{16}S_{30}$ +P_{30} (background)	1	2.0	2.7	0.6	23.8
	2	2.0	2.7	0.6	25.0
	3	1.9	2.7	0.6	26.4
Background + $N_{30}P_{30}K_{30}$ (local application)	1	1.9	2.6	0.6	27.2
	2	1.9	2.6	0.6	28.3
	3	1.9	2.6	0.6	29.9
Background + $N_{45}P_{45}K_{45}$ (local application)	1	1.8	2.5	0.6	29.7
	2	1.8	2.5	0.6	31.1
	3	1.8	2.5	0.6	32.5
Background + $N_{60}P_{60}K_{60}$ (scattering application)	1	1.9	2.6	0.6	28.0
	2	1.9	2.6	0.6	29.6
	3	1.9	2.6	0.6	31.1
Variety Granada					
Without fertilizers (control)	1	1.3	1,8	0.5	25.3
	2	1.3	1.8	0.5	26.3
	3	1.3	1.8	0.5	27.7
40 t/ha of semi-rotted manure under the predecessor + $K_{56}Mg_{16}S_{30}$ +P_{30} (background)	1	1.2	1.7	0.5	31.6
	2	1.2	1.7	0.5	32.6
	3	1.1	1.6	0.5	34.3
Background +	1	1.1	1.6	0.4	36.3

$N_{30}P_{30}K_{30}$ (local application)	2	1.1	1.6	0.4	37.6
	3	1.1	1.6	0.4	39.2
Background + $N_{45}P_{45}K_{45}$ (local application)	1	1.0	1.5	0.4	38.3
	2	1.0	1.5	0.4	39.6
	3	1.0	1.5	0.4	41.1
Background + $N_{60}P_{60}K_{60}$ (scattering application)	1	1.1	1.6	0.4	37.3
	2	1.1	1.6	0.4	38.5
	3	1.1	1.6	0.4	40.1
Variety Memphis					
Without fertilizers (control)	1	1.8	2.8	0.9	21.3
	2	1.8	2.8	0.9	22.1
	3	1.8	2.8	0.9	23.3
40 t/ha of semi-rotted manure under the predecessor + $K_{56}Mg_{16}S_{30}$ +P_{30} (background)	1	1.7	2.7	0.8	30.0
	2	1.7	2.7	0.8	30.9
	3	1.7	2.7	0.8	32.6
Background + $N_{30}P_{30}K_{30}$ (local application)	1	1.6	2.6	0.8	31.4
	2	1.6	2.6	0.8	32.9
	3	1.6	2.6	0.8	34.5
Background + $N_{45}P_{45}K_{45}$ (local application)	1	1.5	2.5	0.8	33.2
	2	1.5	2.5	0.8	35.2
	3	1.5	2.5	0.8	36.7
Background + $N_{60}P_{60}K_{60}$ (scattering application)	1	1.6	2.6	0.8	32.9
	2	1.6	2.6	0.8	34.0
	3	1.6	2.6	0.8	35.6
HIP_{05}: 2019 A – 0.16; B – 0.16; C – 0.21; AB – 0.29; AC – 0.36; BC – 0.37; ABC – 0.64; 2020 A – 0.15; B – 0.15; C – 0.2; AB – 0.27; AC – 0.35; BC – 0.36; ABC – 0.62; 2021 A – 0.24; B – 0.24; C – 0.31; AB – 0.42; AC – 0.53; BC – 0.53; ABC – 0.93					

It should be noted that potato varieties differed in their resistance to disease. The highest resistance to Rhizoctonia violaceae and Common scab was noted in the variety Granada. The affection of tubers of this variety by Rhizoctonia violaceae did not exceed 1.3%; the affection by Common scab did not exceed 1.8%.
In general, the affection of tubers by both Rhizoctonia violaceae and Common scab was reduced by 0.1-0.3% with the intensification of technological methods of cultivation (application of different methods and rates of fertilizers, fractions of planting material).

The analysis of influencing factors on the studied elements shows that the predominant share of the impact on the affection of potato varieties by Rhizoctonia violaceae belongs to genotypic characteristics – 92.48%. The impact of the fraction of planting material was also significant – 7.0%. The share of the influence of fertilizer, as well as the interaction of these factors, was lower, except for the interaction of the fraction of planting material with fertilizer – 0.3%, which turned out to be significant (Fig. 1).

The higher affection of potato tubers by Rhizoctonia violaceae and Common scab was noted in the early-ripening variety Laperla, but it did not exceed 2.2 and 2.9%. The improvement of the agro background of cultivation provided a slight reduction in tuber affection – 0.2-0.3%, respectively.
The variety Memphis was characterized by lower resistance to Rhizoctonia violaceae and Common scab compared to the variety Granada, but its resistance was higher compared to the variety Laperla. The affection of potato tubers by Rhizoctonia violaceae and Common scab in this variety did not exceed 1.8 and 2.8%. The use of the researched technological methods of cultivation contributed to a slight decrease in tuber affection – 0.2-0.3%. A slight increase in affection by Rhizoctonia violaceae was noted in 2020.

It should be noted that the share of influence on the affection by Common scab mostly depended on genotypic characteristics (96.0%) and on the fraction of planting material (3.7%). The share of the influence of fertilizer, as well as the interaction of these factors, was lower (Fig. 2).

The plant affection by viral diseases was determined in field conditions in the phase of budding and flowering. At the same time, the affection of plants by viral diseases, providing the annual removal of diseased plants, depended primarily on the conditions of the year of research and varietal characteristics and varied from 0.5% in the variety Granada to 0.9% in the variety Memphis, while it did not exceed 0.7% in the variety Laperla. A slightly higher affection by viral diseases was noted in 2019 and 2020. Since the year 2019 was hotter than others, and the year 2020 saw a slightly lower amount of precipitation, that is, these years turned out to be more favorable for the flight of aphids.

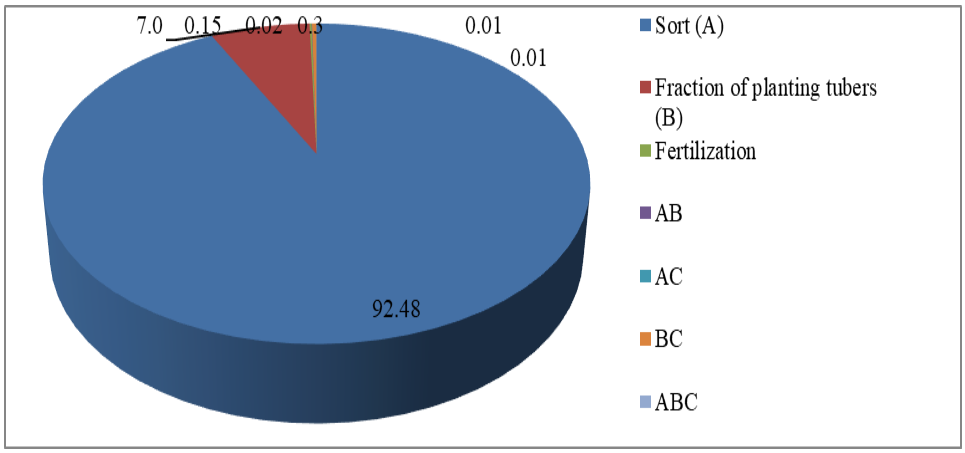

Figure 1. Shares of influence of varietal characteristics, fractions of planting material and fertilizer on the affection of potato varieties by Rhizoctonia violaceae

The affection by Aukuba-mosaic depended on genotypic characteristics (95.05%) and on the fraction of planting material (4.33%). The share of influence of fertilizer, as well as the interaction of these factors, was lower (Fig. 3).

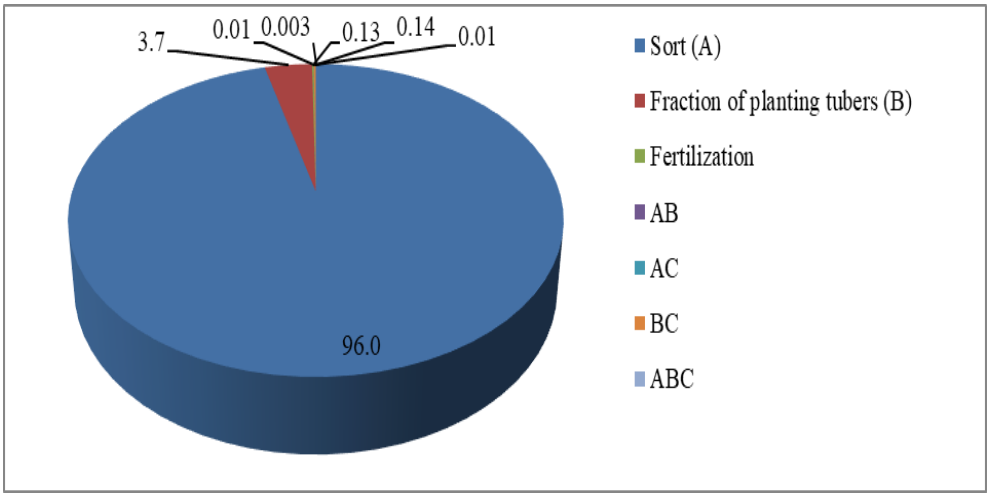

Figure 2. Shares of influence of varietal characteristics, fractions of planting material and fertilizer on the affection of potato varieties by Common scab.

The yield of potatoes depended on the methods and rates of fertilizers, fraction of planting material and varietal characteristics. It should be noted that an increase in the fraction of planting tubers led to an increase in the level of potato yield under different methods and rates of applied fertilizers among all potato varieties studied in the experiments.

Among the studied varieties, the yield indicators of the variety Granada were the best, which was noted in all options of the experiment. The highest productivity indicators were noted in the experimental option, where local application of mineral fertilizers in the dose of $N_{45}P_{45}K_{45}$ was carried out against the background of the effect of semi-rotted manure applied under the predecessor.

The yield increased from 38.3 to 41.1 t/ha. It is by 13.0-13.4 t/ha higher than in the control option. The experimental option, where mineral fertilizers in the dose of $N_{60}P_{60}K_{60}$ were applied by scattering against the background of Potassium magnesium fertilizer and the effect of semi-rotted manure, provided a lower yield from 37.3 to 40.1 t/ha, compared to the previous option.

The fraction of planting material increased. It is by 12.0-12.4 t/ha higher than in the control option and indicates a lower efficiency of the effect of scattering application compared to local application, during which fertilizers are placed at a certain soil depth with better moisture supply. A zone with an increased concentration of nutrients is formed, which are more fully used by plants during the growing season.

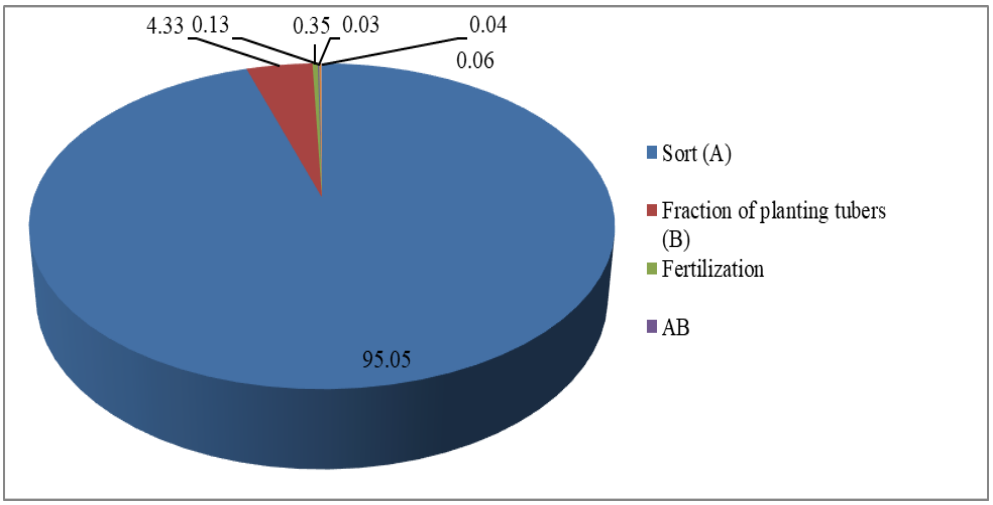

Figure 3. Shares of influence of varietal characteristics, fractions of planting material and fertilizer on the affection of potato varieties by Aukuba-mosaic.

The mid-ripening variety Memphis, according to all experimental options, provided intermediate indicators in terms of the elements of the crop structure and yield level between the mid-early variety Granada and the early-ripening variety Laperla, which are better in terms of these indicators.

CONCLUSIONS

- Potato varieties differed in their resistance to disease. The highest resistance to Rhizoctonia violaceae and Common scab was noted in the variety Granada. The affection of tubers of this variety by Rhizoctonia violaceae did not exceed 1.3%; the affection by Common scab did not exceed 1.8%. The higher affection of potato tubers by Rhizoctonia violaceae and Common scab was noted in the early-ripening variety Laperla and did not exceed 2.2 and 2.9%. The improvement of the agro background of cultivation provided a slight reduction in tuber affection – 0.2-0.3%, respectively. The variety Memphis was characterized by lower resistance to Rhizoctonia violaceae and Common scab compared to the variety Granada, but its resistance was higher compared to the variety Laperla. The affection of potato tubers by Rhizoctonia violaceae and Common scab in this variety did not exceed 1.8 and 2.8%. The affection of plants by viral diseases, providing the annual removal of diseased plants, depended primarily on the conditions of the year of research and varietal characteristics and varied from 0.5% in the variety Granada to 0.9% in the variety Memphis, while it did not exceed 0.7% in the variety Laperla.

- The conducted analysis of the influence of factors on disease affection indicated a significant share of the impact of genotype resistance – from 92.5 to 96.0%, as well as of the fraction of planting material – from 3.7 to 7.0%. The influence of other factors and their interaction was not significant. Therefore, the introduction of disease-resistant varieties into production and the use of the optimal fraction of planting material will reduce the pesticide load on the environment by reducing the volume of their use.

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