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RESEARCH ARTICLE

Effectiveness of the combined application of micro-fertilizers and fungicides on the beets crops

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The purpose of the research was to find out the effect of foliar fertilization with complex microfertilizers together with fungicides on the growth and development of plants and the yield of beet root in the Western Forest Steppe. **Methods.** Field, analytical and statistical. **Results.** It was found that the foliar fertilization of ADOB micro and macrofertilizers with the fungicide Impact in the Harold variety – 61.46 thousand m^2/ha, and in Kestrel – 73.06 thousand m^2/ha, provided the largest leaf area. The highest photosynthetic potential was in the Kestrel variety with foliar ADOB macro+micro compatibility with the Impact fungicide (2.37 million m^2 × days/ha). Foliar fertilization of ADOB microfertilizers macro+micro with application rate of 2.0 kg/ha and fungicide Impact with application rate of 0.25 l/ha provides the highest weight of Harold root crops for the harvesting period at 413.0 g and Kestrel variety – 516.1 g. The introduction of ADOB macro+micro complex microfertilizers, in combination with Topsin M and Impact fungicides, provided the highest yield of beet root in Harold variety – 62.0-62.2 t/ha and Kestrel variety – 75.4-77.4 t/ha. The highest solids content and sugars were also observed in the variant, where they applied foliar ADOB macro+micro compound fertilizers with Topsin M and Impact fungicides in Harold variety - 15.6-15.7% and 8.5%, in Kestrel variety – 16.0-16.1% та 8.9%, respectively. The foliar fertilization of ADOB microfertilizer macro+micro in combination with the fungicide Impact provided the highest betanin content of 352.5 mg/100 g of raw weight in the Harold variety, and 270.9 mg/100 g of raw weight in the Kestrel variety. The combined application of ADOB microfertilizers macro+micro and fungicide Impact allowed to obtain maximum rates of profitability in the Kestrel variety - 241.6%, in the Harold variety - 182.3%.
Keywords: beet; variety; foliar fertilization; root crops; microfertilizers

Introduction

Agrotechnological methods of cultivation in the conditions of today do not fully contribute to the realization of the yielding genetic potential of new varieties of beet, which is due to the lack of compliance of agrotechnology with the biological characteristics of modern varieties. Due to this fact, there is a problem of improving the elements of agricultural technology in order to adapt them to the biological characteristics of plants, which will maximize the use of their yield potential (Kuts, 2007). To increase the level of realization of the beetroot biological potential, it is important to introduce into the production of modern effective competitive agrotechnology, which should be based on the selection of adapted for the area of high-yielding varieties, optimizing the conditions of macro and micronutrient nutrition, the use of modern means of protection. The use of microfertilizers is a reserve for increasing yields and improving the quality of root crops. The microelements included in their composition activate the activity of many enzymes, increase the energy of seed germination, reduce the incidence of plants by bacterial and fungal diseases (Sanin and Sanin, 2012; Elkner et al., 2006).

According to A.S. Zaryshniak, I.M. Zherdetsky, microelements accelerate the development of crops, increase the resistance of plants to lack of moisture and low temperatures and absorption of nitrogen, phosphorus and potassium from the soil (Zaryshniak and Zherdetsky, 2007). The positive effect on plants of microelements is also caused by the fact that they participate in the redox processes of carbohydrates of the environment. Under the influence of microelements in the leaves increases the composition of chlorophyll, improves photosynthesis, increases the assimilating effect of the plant (Bundinienė et al., 2007). M. Imran and Z.A. Gurmani have proved that beet is sensitive to micro elements (Imran and Gurmani, 2011). Therefore, their use is indispensable for the cultivation of this culture, while using foliar fertilization. Microelements activate and support photosynthesis, increase the efficiency of macro fertilizers, create an anti-stress effect from the use of pesticides, increase the quantity and quality of the crop (Ovcharuk et al., 2019; Archer, 1988). Today, chelate-based microfertilizers have become widespread, 5-10 times more effective than inorganic salts due to their faster incorporation into plant biochemical processes. In addition, chelating forms of micronutrient fertilizers are absorbed by almost 100% due to which the application rate is reduced to 1-2 kg/ha.

One of the factors behind the low productivity of beet is the defeat of plants by numerous diseases of different etiology, which significantly reduce both the productivity and the quality of the harvest. Depending on the intensity of disease development, crop failure may reach 25-30%, and in the years of epiphytoties - 50-65% or more (Bezvikonnyi, 2018; Markoski et al., 2015). The use of microfertilizers contributes to the reduction of plant disease by diseases, which is explained by the ability of trace elements to improve the immune properties of plants to diseases and the presence of trace elements (primarily in copper and zinc) fungicidal properties (Petek et al., 2017; Bulygin et al., 2007). However, without the use of fungicides, it is impossible to achieve a high effect in the control of beet disease with microfertilizers alone. Therefore, an important component of the protection system of beet plants is the use of fungicides, as the annual loss of yield from diseases is about 30%, and in the late and not qualitative conduct of protective treatments

- 50% or more (Pethybridge et al., 2017; Lykhochvor and Kostiuchko, 2015).
Improvement of the chemical method of control with the use of new low- and non-toxic for the biosphere and human, highly effective, selective chemicals is of great importance today. In addition, the introduction of new fungicides reduces the risk of developing resistant strains of pathogens (Xu et al., 2011; Stefanyuk, 2004; Shkolnik, 1974). A priority for solving this problem is the joint use of fertilizers and fungicides. Without the use of fertilizers and fungicides, it is not possible to achieve high yields and improve the quality of root crops in modern technologies. Therefore, the search for the most effective model of microfertilizers and fungicides application is relevant in modern technologies of beet cultivation.
The aim of our research was to study the effect of different foliar fertilization variants with complex microfertilizers and the use of modern crop protection agents on the yield and biochemical indices of beet root in the Western Forest Steppe.

Methods

The study of the effect of foliar fertilization with complex fertilizers and the use of fungicides on the yield and biochemical parameters of beet root was conducted during the 2015-2017 years at the experimental field of Podillya State Agricultural and Technical University Training Center. Soil of the experimental field is black soil typical leached, little humus, medium loam on forest loam. The humus content (according to Tyurin) in the soil layer 0-3 cm is 3.6-4.2%. The content of easily hydrolyzable nitrogen compounds (Kornfield) is 90-127 mg/kg (high), mobile phosphorus (Chirikov) 138-174 mg/kg (high) and potassium exchange (Chirikov) - 145-185 mg/kg of soil (high). The amount of absorbed bases ranges from 163-205 mg eq/kg. Hydrolytic acidity is 17-22 mg eq/kg, the degree of saturation of the basics - 90%. The size of the sowing area is 20 m^2, accounting - 15 m^2, the repetition of the experiment - four times. Beetroot varieties Kestrel and Harold were grown.
Foliar fertilization of plants by microfertilizers was carried out in the phase of leaf closure in rows. The investigated forms of complex fertilizers: Avangarde P Beet - composition: N - 50 g/l, K_2O - 10 g/l, MgO - 60 g/l, B - 6 g/l, Fe - 2 g/l, Mn - 15 g/l, Cu - 5 g/l, Zn - 7 g/l, Mo - 0,10 g/l, Co - 0,10 g/l. Application rate - 2 l/ha. Sani Mix - composition: N - 50 g/l, P2O5 - 40 g/l, K_2O - 10 g/l, MgO - 5 g/l, B - 5 g/l, Fe - 10 g/l, Mn - 10 g/l, Cu - 10 g/l, Zn - 10 g/l, Mo - 0.10 g/l, Co - 0.05 g/l. Application rate - 1.0 l/ha. Intermag - beet - composition: N - 194 g/l, Na_2O - 39,0 g/l, MgO - 26,0 g/l, SO_3 - 24,0 g/l, B - 6.45 g/l, Fe - 2.6 g/l, Mn - 8.4 g/l, Cu - 2.6 g/l, Zn - 6.5 g/l, Mo - 0.065 g/l, Ti - 0.26 g/l. Application rate - 2 l/ha. ADOB macro + micro - composition: N - 10%, P_2O_5 - 5, K_2O - 15, MgO - 10, B - 1.0, Cu - 0.01, Fe - 0.02, Mn - 0.05, Mo - 0.01, Zn - 0.01, S - 5.0%. Application rate - 2 kg/ha.
Fungicides were introduced at the same time as foliar fertilization in the leaf closure phase in rows. The following fungicides were used in the studies: Impact 25, K.S. - 0.25 l/ha, Topsin-M 500, KS - 1.2 l/ha. Phenological observations, biometric and physiological-biochemical studies were performed according to G.L. Bondarenko and K.I. Yakovenko (2001).

Results

The productivity of growth processes in beet is achieved by increasing the assimilation surface, because, due to the assimilants formed during photosynthesis in the leaves, is the active formation of roots. The results of the study showed (Table 1) that fertilizers had a positive effect on the increase in the area of assimilation surface of beetroot varieties Harold and Kestrel. It was found that more intensive growth of leaf surface was observed in Kestrel plants.
The highest rate of growth of the assimilation surface was observed in the variant where ADOB macro+micro complex fertilizers were used together with the Impact fungicide. In the Harold variety it was 61.46 thousand m^2/ha, and in Kestrel 73.06 thousand m^2/ha. On the variants where ADOB complex fertilizers were applied macro+micro in combination with Topsin M fungicide, the level of this indicator was in the range of 59.80 and 69.00 thousand m2/ha for Harold and Kestrel varieties, respectively.
In the variant used in the foliar fertilization complex fertilizers Intermag-beet and Sani Mix together with fungicides the area of leaf surface was 53.57-57.69 thousand m^2/ha, and in Kestrel 65.07-67.67 thousand m^2/ha, and on variants without application of fungicides - 49.16-53.12 thousand m^2/ha, and 62.12-63.19 thousand m^2/ha, respectively.
The use of Avangard P Beet complex fertilizer in foliar fertilization in combination with fungicides had the least impact on the analyzed indicator over the study period.
It should be noted that the foliar fertilization of beet with microfertilizers together with the Impact and Topsin M fungicides allows to obtain a minimum percentage of disease prevalence on beet crops.
Photosynthetic potential characterizes the duration of the leaf surface during a certain period, which is determined in million $m^2 \times$ days/ha. According to the results of experimental studies, the highest photosynthetic potential was in the Kestrel variety with the foliar ADOB macro+micro compatibility with the Impact fungicide (2.37 million $m^2 \times$ days/ha). A slightly lower value of this indicator was noted in the variant with the application of Topsin M fungicide - 2.31 million $m^2 \times$ days/ha, respectively. A similar pattern averaged over 2015-2017 in the Harold variety - 1.90 and 1.85 million $m^2 \times$ days/ha, respectively.
Foliar fertilization with micronutrients contributed to the increase of photosynthetic potential during the vegetation period of beet compared with the control by 21.8% in the Harold variety and 24.1% in the Kestrel variety. The introduction of fungicides compared to the variant without their use contributed to the increase of photosynthetic potential by 13.8% in the Harold variety and 16.2% in the Kestrel variety, respectively. The use of fungicides in general contributed to the intensification of photosynthesis processes, the growth of root vegetables and the accumulation of spare nutrients in it.
On the whole, the interpretation of the result of the above calculations makes it possible to establish the proportion of the influence of the studied factors on the area of the leaf surface of the beet (Figure 1).
On average for 2015-2017, the share of the impact of the variety on the formation of leaf area was 52.1%, foliar fertilization by microfertilizers 14.4%, the use of fungicides 4.8%. The combination of the influence of varietal features and the introduction of microfertilizers was 3.4%. Interaction of variety, foliar application of microfertilizers and fungicides - 3.4%, microfertilizers and fungicides - 2.6%.

Table 1. Biological parameters and productivity of beet depending on foliar fertilization and protection of plants against diseases (average for 2015-2017).

Variety	Foliar fertilization	Fungicide	Leaf area, thousand m^2/ha (20.07)	Photosynthetic potential, million m^2 × days/ha (20.07)
Harold	Control without fertilizers	Control without fungicides	47.37	1.56
		Topsin M	49.96	1.64
		Impact	50.55	1.67
	Avangard P Beet	Control without fungicides	48.72	1.58
		Topsin M	53.93	1.72
		Impact	54.13	1.74
	Intermag-Beet	Control without fungicides	53.12	1.70
		Topsin M	56.31	1.82
		Impact	57.69	1.84
	Sani Mix	Control without fungicides	49.16	1.61
		Topsin M	53.57	1.70
		Impact	54.28	1.78
	ADOB macro+micro	Control without fungicides	56.39	1.82
		Topsin M	59.80	1.85
		Impact	61.46	1.90
Kestrel	Control without fertilizers	Control without fungicides	60.93	1.91
		Topsin M	64.14	2.02
		Імпакт	64.36	2.04
	Avangard P Beet	Control without fungicides	62.42	1.95
		Topsin M	65.36	2.11
		Impact	66.74	2.19
	Intermag-Beet	Control without fungicides	63.19	1.97
		Topsin M	65.07	2.08
		Impact	67.67	2.21
	Sani Mix	Control without fungicides	62.12	1.92
		Topsin M	65.95	2.18
		Impact	67.11	2.25
	ADOB macro+micro	Control without fungicides	65.70	2.18
		Topsin M	69.00	2.31
		Impact	73.06	2.37
LSD 05 general			8.97	0.16
Varieties			2.75	0.10
Microfertilizers			1.62	0.06
Fungicides			1.32	0.07

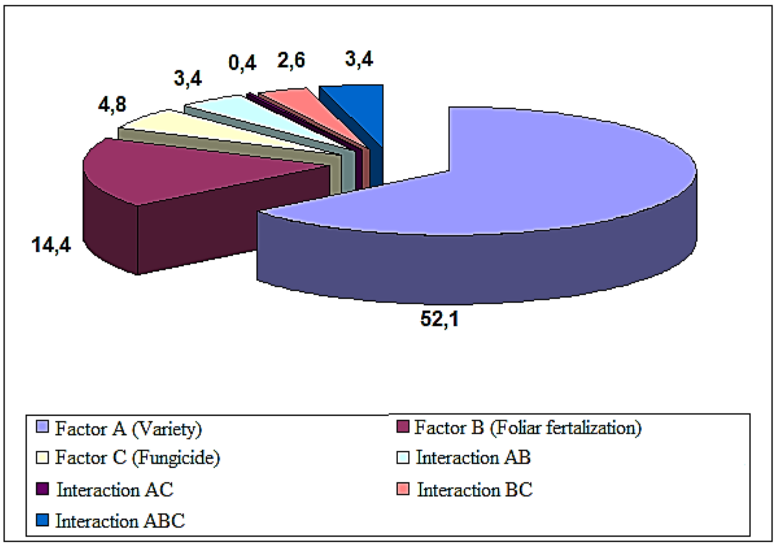

Fig. 1. Shares of influence factors on the area of leaf surface of beet (20.07), 2015-2017.

The dependence of photosynthetic potential on the leaf surface area of beet in Harold and Kestrel varieties is described by the following equation of approximation y = -0.02 +0.03x and explains 98% of the variation of the variable r = 0.98 (Figure 2).

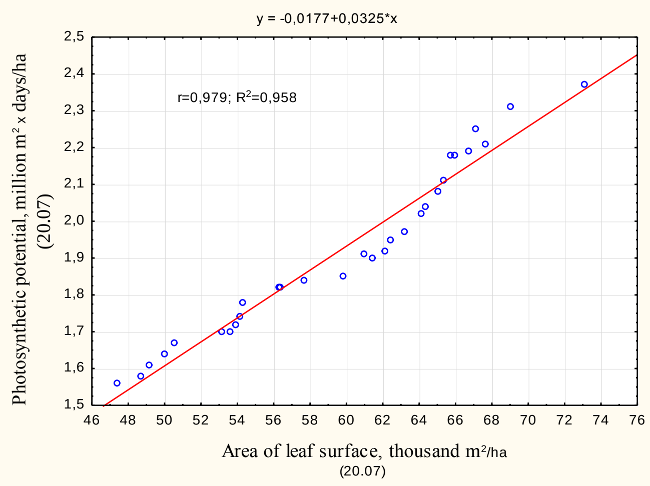

Fig. 2. Interrelation between photosynthetic potential and area of leaf surface of beet (average for 2015-2017).

Experimental studies have established (Figure 3) that plant productivity is correlated with photosynthetic potential and has a straight-line character: y=-0.49+33.31x, correlation coefficient r=0.99. This indicates a close correlation between the studied indicators.

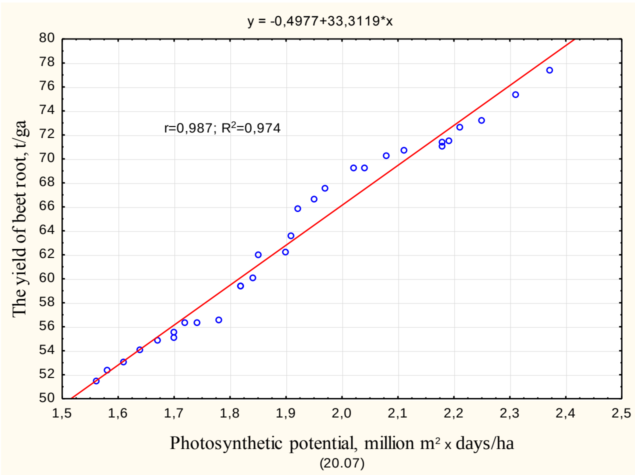

Fig. 3. Interrelation between photosynthetic potential and the yield of beet root (average for 2015-2017).

Thus, the productivity increase of beet root is due to the foliar fertilization of complex microfertilizers, especially ADOB macro+micro, which allowed to obtain 59.40 t/ha in Harold variety and 71.10 t/ha, respectively. Under the influence of fungicides, the growth processes were more intensive than the unprocessed variant due to the effective protection of the leaf apparatus against diseases, which resulted in an increase in the yield on the variants with the introduction of ADOB macro+micro fertilizer in the Harold variety by 4.7% and in the Kestrel variety by 8.4%. The results of the study of the dynamics of beet root weight growth (table 2) show that in the initial stages of growth and development, the weight of beet root was small, and in the interlacing phase the average weight of beet root Harold was 96.7 g, and Kestrel variety - 109.5 g.

In the variants with application of microfertilizers as fertilization indicators of the average weight of roots were observed, which ranged from 95.4 to 106.2 g for the Harold variety and from 109.3 to 110.52 g for Kestrel variety, at the same time, as in the control variants, the variability of the studied index was 95.8-95.9 and 108.9-109.2 g, respectively. It is worth saying that basically the deviation of the weight of root crops were within the error of LSD, as the application of the elements of cultivation technology of beetroot studied by us only occurred and significant differences in the reaction to different variants of foliar fertilization by microfertilizers could not be, because the plants in a few days slightly increased their weight. Subsequently, as the growth and development of beet plants, the weight of root crops increased and as of the harvesting period, the average for the experiment was 421.7 g, while the average for the Harold variety was 377.2 g, and the Kestrel variety – 469.2 g. At later stages of growth and development of beet, the difference between control variants of the experiment as compared to the application of foliar fertilization, there are differences in the growth of root weight. Thus, as of the harvesting period, on average, on the control variant of the Harold variety, the weight of one root crop was 356.6 g, and under the condition of foliar application with microfertilizer Avangard P Beet - 366.4 g, which is 9.1 g more than the control variant. The use of Intermag-beet fertilizer contributed to the increase of root weight by 31.4 g, while the maximum deviation of the test trait from the control variants was subject to the use of ADOB macro+micro - 51.2 g. The same tendency of increase in root weight was obtained in the use cases of microfertilizers in Kestrel variety. Thus, with an average root weight of the control variant of 449.0 g, and the use of fertilizers Intermag-beet and ADOB macro+micro on average, according to the variants provided weight gain of root crops, respectively, by 18.7 and 48.6 g. Positive effect on the increase in the weight of root beet was preserved both on variants with the use of foliar fertilization, and on variants with the use of fungicides against diseases. Thus, on control variants as of the harvesting period (without the use of microfertilizers), subject to the application of Topsin M fungicide on the crops of the Harold variety, the weight gain of the root crop was 21.4, and of the Kestrel variety - 29.6 g compared with the control variant. The use of the Impact fungicide contributed to an increase in the weight of root crops compared to the control by 24.5 and 38.9 g, respectively. Therefore, based on the results of studies, it can be concluded that the use of ADOB macro+micro fertilizers with foliar application rate of 2.0

kg/ha and fungicide with the application rate of 0.25 l/ha provides the largest weight of Harold root crops for the harvest period at the level of 413.0 g and Kestrel variety - 516.1 g, respectively (Fig. 4).

Table 2. Dynamics of weight growth of beet root (average for 2015-2017).

Variety	Foliar fertilization	Fungicide	closing in the rows	harvesting
Harold	Control without microfertilizers	Control without fungicides	95.8	343.3
		Topsin M	95.8	360.7
		Impact	95.9	365.7
	Avangard P Beet	Control without fungicides	95.4	349.0
		Topsin M	96.5	375.3
		Impact	95.8	375.0
	Intermag-Beet	Control without fungicides	95.6	367.5
		Topsin M	96.3	395.8
		Impact	95.9	400.8
	Sani Mix	Control without fungicides	96.1	353.9
		Topsin M	96.5	369.9
		Impact	96.2	377.4
	ADOB macro+micro	Control without fungicides	95.7	395.8
		Topsin M	96.1	414.6
		Impact	106.2	413.0
Kestrel	Control without microfertilizers	Control without fungicides	109.2	424.2
		Topsin M	109.1	461.3
		Impact	108.9	461.4
	Avangard P Beet	Control without fungicides	109.6	444.3
		Topsin M	109.3	471.6
		Impact	109.5	476.7
	Intermag-Beet	Control without fungicides	109.8	450.4
		Topsin M	109.3	468.5
		Impact	109.5	484.1
	Sani Mix	Control without fungicides	109.6	438.8
		Topsin M	110.2	475.9
		Impact	109.6	488.2
	ADOB macro+micro	Control without fungicides	109.9	474.3
		Topsin M	109.4	502.5
		Impact	110.2	516.1
LSD 05 general			6.89	51.37
varieties			3.69	16.73
microfertilizers			2.46	9.73
fungicides			3.26	9.65

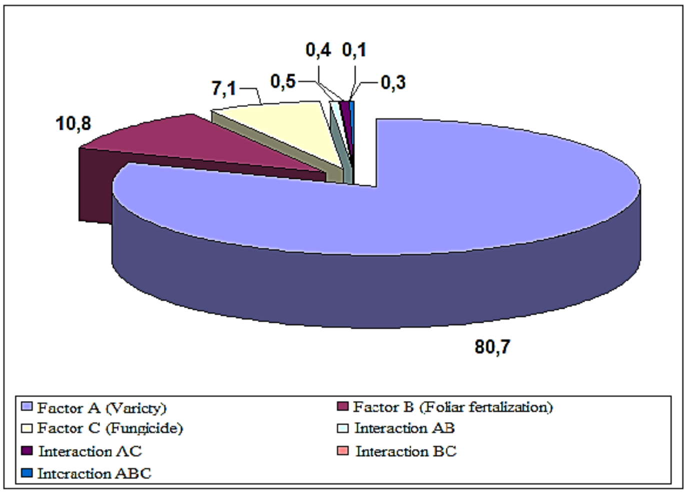

Fig. 4. Share of influence factors on weight of beet roots for harvesting period, 2015-2017.

The results of the analysis of variance confirm that largely the cultivation (factor A) - 80.7%, the foliar application of microfertilizers (factor B) - 10.8%, the use of fungicides (factor C) influenced the formation of the weight of beet root in the study period.) - 7.1%. Yield is a major indicator of the productivity of beet root. The results of the studies (Table 3) show that this indicator depended largely on the biological characteristics of the varieties and agroclimatic conditions of cultivation.

Table 3. Influence of foliar fertilization and fungicides on the productivity of beet root, t/ha, (2015-2017).

Variety	Foliar fertilization	Fungicide	Productivity, t/ha			
			2015	2016	2017	Average for 2015-2017
Harold	Control without fertilizers	Control without fungicides	48.9	54.4	51.2	51.50
		Topsin M	52.6	56.3	53.5	54.10
		Impact	53.3	57.2	54.2	54.90
	Avangard P Beet	Control without fungicides	51.7	53.8	51.8	52.40
		Topsin M	54.4	58.4	56.0	56.30
		Impact	54.8	58.1	56.0	56.30
	Intermag-Beet	Control without fungicides	53.1	56.7	55.6	55.10
		Topsin M	58.6	60.1	59.5	59.40
		Impact	59.2	61.3	59.7	60.10
	Sani Mix	Control without fungicides	52.5	53.9	52.9	53.10
		Topsin M	54.5	56.6	55.3	55.50
		Impact	55.5	57.7	56.6	56.60
	ADOB macro+micro	Control without fungicides	57.8	61.2	59.1	59.40
		Topsin M	61.5	63.3	61.1	62.00
		Impact	60.6	63.9	62.0	62.20
Kestrel	Control without fertilizers	Control without fungicides	60.4	67.1	63.2	63.60
		Topsin M	67.2	72.0	68.4	69.20
		Impact	65.9	73.3	68.3	69.20
	Avangard P Beet	Control without fungicides	64.4	69.6	65.8	66.60
		Topsin M	69.1	73.0	69.9	70.70
		Impact	66.5	74.3	73.6	71.50
	Intermag-Beet	Control without fungicides	63.9	72.2	66.7	67.60
		Topsin M	65.8	74.9	70.2	70.30
		Impact	70.3	75.7	71.7	72.60
	Sani Mix	Control without fungicides	65.0	66.8	65.5	65.80
		Topsin M	70.1	72.9	71.1	71.40
		Impact	70.3	75.7	71.7	73.20
	ADOB macro+micro	Control without fungicides	69.3	73.2	70.7	71.10
		Topsin M	74.6	76.3	75.2	75.40
		Impact	75.4	78.8	77.9	77.40
	LSD 05 general					5.32
	varieties					1.52
	microfertilizers					0.88
	fungicides					1.18

Yields have also varied over the years, as affected by adverse weather conditions in 2015. The productivity of root crops in the variant without micro fertilizers and without the application of fungicides this year (2015) was 48.9 t/ha in the Harold variety, which is 5.5 t/ha less than in 2016 and 60.4 t/ha in the Kestrel variety, which is 6.7 less respectively. On average, three years on the control variant, the highest yields were characterized by plantations of the Kestrel variety - 63.6 t/ha, which was 12.1 t/ha higher than the Harold variety (51.5 t/ha). Foliar fertilization of various complex microfertilizers together with fungicides contributed to a significant increase in the yield of beet root during all the years of research. Comparing the humidity conditions for the years of research, it should be noted that beet growth was more favorable for the growth and development of beet plants in 2016. In April-September 2016, 308.9 mm of precipitation fell, whereas in 2015, the amount of precipitation was 176.7 mm. for the same time period. Thus, in 2016, the highest yield was obtained for the cultivation of beet, where they made microfertilizers ADOB macro+micro together with fungicides Impact and Topsin M. At the same time, the yield of root crops was in the Harold variety – 63.3-63.9 t/ha and in the Kestrel variety - 76.3- 8.8 t/ha.

The results of the 2017 studies indicate that the highest root yields were due to the co-application of ADOB macro+micro fertilizer together with the Impact fungicide in both studied varieties. Thus, the yield of the Harold variety was 62.0 t/ha, and the Kestrel variety - 77.9 t/ha, which is 21.1% and 23.3% higher compared to the control. The combined application of fungicides with foliar fertilization by microfertilizers had a greater impact on yield than on separate application. Thus, in the Harold variety, on the variants with the introduction of ADOB macro+micro but without the use of fungicides, the yield of beet root was 59.1 t/ha, and Kestrel variety - 70.7 t/ha, respectively. For an average of three years, with the application of fungicides, the yield increase compared to the control on variants without microfertilizers was 2.6-3.4 t/ha in the Harold variety and 5.6 t/ha in the Kestrel variety. The highest yield was characterized by the variant, where foliar fertilizers were introduced by ADOB macro+micro microfertilizers together with the fungicides Impact and Topsin M, the increase was in the Harold variety - 20.4% and Kestrel - 21.7% compared to the control. Root crop yields were slightly lower when using Avangard P Beet, Intermag-Beet and Sani Mix microfertilizers in combination with fungicides, namely 55.50-60.10 t/ha in the Harold variety and 70.30-73.20 t/ha in the variety Kestrel. In general, the development and prevalence of the disease were more intense in the Topsin M variants than in the Impact fungicide variants, which undoubtedly indicates a higher efficiency of this fungicide. Thus, the use of complex microfertilizers in combination with fungicides allows not only the maximum realization of the biological potential of plants due to the effective absorption of nutrients, but also the high potential of productivity due to the effective protection of the leaf apparatus against diseases that reduce its area and efficiency. The variance analysis of the obtained data shows (Figure 5) that, on average, in 2015-2017, the variety features (A), which accounted for 76.2%, foliar fertilization by microfertilizers (B), had the greatest influence on the formation of the productivity of beet root - 10.1, application of fungicides (C) - 6.8%.

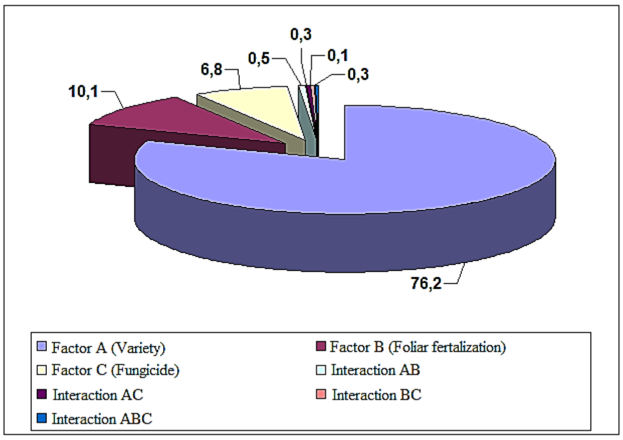

Fig. 5. Share of influence factors on the productivity of beet roots, average for 2015-2017.

The chemical composition of the root crops depends on various factors. These include meteorological conditions of the year, the time of root harvesting, and the degree of their ripeness. It is known that unbalanced macro- and microelements adversely affect some of the quality indicators of root crops. The quality of the root crops is closely linked to the conditions of mineral fertilization and the methods of application of microfertilizers, with proper protection against disease.

The results of the studies (Table 4) showed that in the non-fertilizer variant, the highest solids content was observed in the Kestrel root crops (15.3%), in the Harold variety - 14.3%. The application of microelements in foliar fertilization Avangard P Beet, Intermag-Beet, Sani Mix and ADOB macro+micro contributed to the increase of solid content in Harold root crops: 14.7, 14.6, 14.8, and 15.0%. A similar pattern was observed in the application of foliar fertilization of Kestrel microfertilizers, namely 15.5, 15.7, 15.7, and 15.8%, respectively. This is because in the fertilizer variants the solids were more intensively used for root growth and formation. An increase in the solids content from the combined application of microfertilizers with different fungicides was observed in both Kestrel and Harold varieties.

Co-application of microfertilizers with fungicide Impact of 0.25 l/ha in the Harold variety increased the solids content by 2.7-8.3% and Kestrel varieties by 0.6-3.9%. A similar scheme for the use of microfertilizers with the use of Topsin M with the application rate of 1.2 l/ha provided a solid content of 14.8-15.6% in the Harold variety, which is 6.8% higher compared to without the introduction of fungicides, and in the Kestrel variety at the level of 15.6-16.0%, which is 3.2% higher respectively.

Consequently, the solids content in the roots of beet depended significantly on varietal characteristics. The use of microfertilizers in combination with fungicides helped to increase the content of these substances.

An important indicator of root quality is the content of sugars, which provide their taste, and have a positive effect on the duration of storage. The effect of microfertilizers on the content of sugars, depending on the variety was different. The highest content of total sugars was characterized by root vegetables of the Kestrel variety - 8.5-8.9%, in Harold root crops the sugar content was in the range 6.9-8.5%.

Fertilizer application alone and in combination with fungicides did not significantly increase the amount of sugars. In the control variant, the sugar content was the lowest 6.9% in the Harold variety and 8.5% in the Kestrel variety. The highest content of sugars was observed in the variant, where foliar ADB macro+micro fertilizers were additionally applied together with the fungicides Impact and Topsin M in the Harold variety - 8.5%, which is 1.6% higher than the control variant, in the Kestrel variety (8.9%) which is 0.4% higher. Therefore, it can be said that the variety Kestrel showed only a tendency to increase the amount of sugars. Thus, the sugar content of the root crops was significantly dependent on various factors: the characteristics of the varieties, the weather conditions of the year and the conditions of mineral fertilization.

One important chemical indicator of the composition of beet roots is the content of betanine. Betanine is known to have healing properties. It is able to strengthen the walls of the blood vessels, is a universal tool for the prevention of colds, overload of the body, including carcinogenesis and the effects of radiation. Betanine is also referred to as lipotropic substances, which are actively involved in fat metabolism, contributes to the reduction of blood pressure, increase immunity (Michalik and Grzebellus, 1995; Elbe et al., 1974).

The results of the analysis showed that the highest content of betanine in the non-fertilizer variant was accumulated in the Harold root crops (292.8 mg/100 g wet weight). In Kestrel root crops, their number was at the level of 231.5 mg/100 g of raw weight, which is significantly less than the Harold variety. Fertilizer application increased the content of betanine. However, the combined application of microfertilizers and fungicides contributed to their significant increase in the root crops of both studied varieties.

The foliar fertilization of ADOB microfertilizer macro+micro in combination with the fungicide Impact provided the highest betanine content of 352.5 mg/100 g of raw weight in the Harold variety, and 270.9 mg/100 g of raw weight in the Kestrel variety. A slightly lower level of betanine was in the variants with the application of Topsin M fungicide - 350.3 and 267.3 mg/100 g of raw weight, which is 19.6% and 15.5% higher than the control. The application of microelements into the foliar fertilization of Avangarde P Beet, Intermag-Beet, Sani Mix also contributed to the increase of betanine content in beet root.

It should be noted that the use of complex microfertilizers in combination with fungicides will not only increase the yield, but also improve the biochemical quality of table beet root. In conditions of complex market relations, the efficiency of production of beet root depends on the level of prices for the obtained products, materials, resources, etc. Therefore, the technology of beet growing was evaluated taking into account the production costs, the amount of profit, the cost of 1 ton of production and the level of profitability.

Table 4. Influence of fertilizers and fungicides on biochemical parameters of beet root (average for 2015-2017).

Variety	Foliar fertilization	Fungicide	Solids content, %	sugars, %	betanine mg/100 g, raw weight
Harold	Control without fertilizers	Control without fungicides	14.3	6.9	292.8
		Topsin M	14.4	7.0	299.6
		Impact	14.5	7.1	305.1
	Avangard P Beet	Control without fungicides	14.7	7.2	311.5
		Topsin M	14.8	7.3	315.6
		Impact	15.0	7.4	319.4
	Intermag-Beet	Control without fungicides	14.6	7.5	323.3
		Topsin M	14.8	7.6	326.3
		Impact	14.9	7.8	331.2
	Sani Mix	Control without fungicides	14.8	7.7	332.9
		Topsin M	15.2	8.0	337.7
		Impact	15.4	8.3	340.1
	ADOB macro+micro	Control without fungicides	15.0	8.2	345.8
		Topsin M	15.6	8.5	350.3
		Impact	15.7	8.5	352.5
Kestrel	Control without fertilizers	Control without fungicides	15.3	8.5	231.5
		Topsin M	15.4	8.5	235.4
		Impact	15.5	8.6	238.7
	Avangard P Beet	Control without fungicides	15.5	8.5	239.8
		Topsin M	15.6	8.6	240.6
		Impact	15.6	8.7	244.1
	Intermag-Beet	Control without fungicides	15.7	8.6	254.7
		Topsin M	15.8	8.7	247.3
		Impact	15.8	8.7	250.9
	Sani Mix	Control without fungicides	15.7	8.7	250.0
		Topsin M	15.8	8.7	255.5
		Impact	15.9	8.8	258.2
	ADOB macro+micro	Control without fungicides	15.8	8.8	264.4
		Topsin M	16.0	8.9	267.3
		Impact	16.1	8.9	270.9
LSD 05 general			0.13	0.11	4.65
varieties			0.34	0.61	11.04
microfertilizers			0.19	0.32	6.03
fungicides			0.19	0.15	4.05

All these indicators of economic efficiency are directly dependent on the yield of the crop, except for the cost, which has an inverse relationship. Precise economic justification for the studied elements of cultivation technologies is difficult to obtain today, given the volatility of price parameters. However, the calculation of economic efficiency based on technological maps and prices prevailing for agricultural products and logistical resources, gives a real idea of the use effectiveness of specific agro-techniques for growing beet. The calculation of economic efficiency (Table 5) shows that varietal characteristics, microfertilizers, and the use of fungicides had a significant impact on the level of economic performance.

In the control variant, the amount of production costs is due only to the level of productivity and processes of plant care according to the technological map, while in other variants, the production costs are due to the cost of microfertilizers and fungicides and work on their introduction and work on harvesting additional crops.

The cost per unit of production varied across variants and depended significantly on the level of yield and production costs. Increased productivity has helped to reduce the cost of one ton of root crops. The lowest cost of production was observed in the Kestrel variety with the combined use of ADOB microfertilizers macro+micro and fungicide Impact - 234.2 UAH/ton, and Sani Mix microfertilizer with fungicide Impact - 234.5 UAH/ton. In the Harold variety, the lowest cost was in the combined application of ADOB microfertilizers macro+micro and Impact and Topsin M fungicides - 283.4, and UAH 258.1 UAH/ton, respectively. Therefore, despite the additional costs associated with the use of fertilizers and fungicides, from an economic point of view, they are fully occupied. Thus, the profit in the Kestrel variety from the use of ADOB microfertilizer macro+micro and with the use of fungicide Impact was 43792 UAH/ha and for the use of the Topsin M - 42142 UAH/ha. A similar distribution of profit was observed in the Harold variety in the variants with the introduction of ADOB microfertilizers macro+micro and with the use of Impact and Topsin M fungicides - 32132 and 31922 UAH/ha.

In beetroot Kestrel combined application of microfertilizers ADOB macro+micro and fungicide Impact allowed to obtain maximum rates of profitability – 241.6%, when using micro fertilizers Sani Mix with fungicide Impact – 241.1%, in Harold variety in ADOB microfertilizers macro+micro variants, with the use of Impact and Topsin M fungicides, 182.3% and 180.6%, respectively.

Indicators of cost-effectiveness of growing beet roots depend heavily on the use of fertilizers and fungicides, both individually and in combination, because even at low costs, productivity of plants in particular and crops in general can be significantly improved.

Therefore, from the results of the economic analysis of the research materials, it can be stated that the application of microfertilizers in combination with fungicides provided a sufficiently high level of profitability, which also depended on the natural and price conditions of the production area. For use in production, it is recommended to apply microfertilizers ADOB macro+micro and fungicide Impact for both tested varieties.

Table 5. Economic efficiency of beet root cultivation with the combined application of fertilizers and fungicides (average for 2015-2017).

Variety	Foliar fertilization	Fungicide	Productivity, t/ha	Amount of production costs, UAH	Profit amount, UAH/ha	Cost of 1 t, UAH	Profit amount from 1 ton, UAH	Profitability level,%
Harold	Control without fertilizers	Control without fungicides	51.5	15965.0	25235.0	310.0	490.0	158.1
		Topsin M	54.1	16165.0	27115.0	298.8	501.2	167.7
		Impact	54.9	16115.0	27805.0	293.5	506.5	172.5
	Avangard P Beet	Control without fungicides	52.4	16202.0	25718.0	309.2	490.8	158.7
		Topsin M	56.3	16402.0	28638.0	291.3	508.7	174.6
		Impact	56.3	16352.0	28688.0	290.4	509.6	175.4
	Intermag-Beet	Control without fungicides	55.1	17052.0	27028.0	309.5	490.5	158.5
		Topsin M	59.4	17252.0	30268.0	290.4	509.6	175.4
		Impact	60.1	17202.0	30878.0	286.2	513.8	179.5
	Sani Mix	Control without fungicides	53.1	16517.0	25963.0	311.1	488.9	157.2
		Topsin M	55.5	16717.0	27683.0	301.2	498.8	165.6
		Impact	56.6	16667.0	28613.0	294.5	505.5	171.7
	ADOB macro+micro	Control without fungicides	59.4	17478.0	30042.0	294.2	505.8	171.9
		Topsin M	62.0	17678.0	31922.0	285.1	514.9	180.6
		Impact	62.2	17628.0	32132.0	283.4	516.6	182.3
Kestrel	Control without fertilizers	Control without fungicides	63.6	16465.0	34415.0	258.9	541.1	209.0
		Topsin M	69.2	16665.0	38695.0	240.8	559.2	232.2
		Impact	69.2	16615.0	38745.0	240.1	559.9	233.2
	Avangard P Beet	Control without fungicides	66.6	16702.0	36578.0	250.8	549.2	219.0
		Topsin M	70.7	16902.0	39658.0	239.1	560.9	234.6
		Impact	71.5	16852.0	40348.0	235.7	564.3	239.4
	Intermag-Beet	Control without fungicides	67.6	17552.0	36528.0	259.6	540.4	208.1
		Topsin M	70.3	17752.0	38488.0	252.5	547.5	216.8
		Impact	72.6	17702.0	40378.0	243.8	556.2	228.1
	Sani Mix	Control without fungicides	65.8	17017.0	35623.0	258.6	541.4	209.3
		Topsin M	71.4	17217.0	39831.6	241.1	557.9	231.4
		Impact	73.2	17167.0	41393.0	234.5	565.5	241.1
	ADOB macro+micro	Control without fungicides	71.1	17978.0	38902.0	252.9	547.1	216.4
		Topsin M	75.4	18178.0	42142.0	241.1	558.9	231.8
		Impact	77.4	18128.0	43792.0	234.2	565.8	241.6

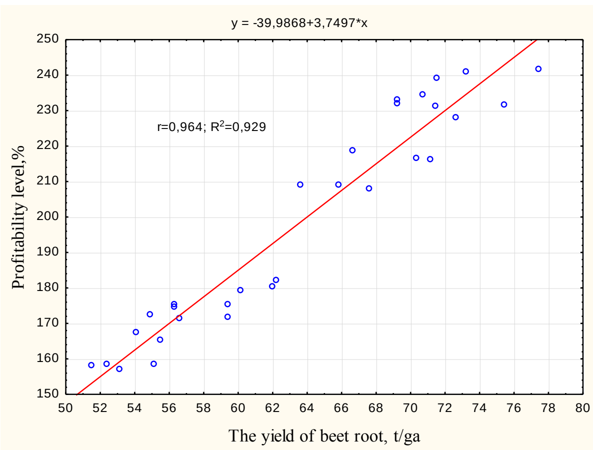

Fig. 6. Interrelation between the profitability level and the yield of beet root (average for 2015-2017).

Experimental studies have established (Figure 6) that the level of profitability is correlated with the productivity of beet root and has a straight line character: y=-39.98+3.75x, coefficient of determination R2=0.93. This indicates that 93% of the total variation in the level of profitability is due to the yield of beet root, and 7.1% is due to other factors.

Conclusions

The largest area of leaf surface was provided by the foliar fertilization of ADOB microfertilizers macro+micro with fungicide Impact in the Harold variety - 61.46 thousand m^2/ha, and in Kestrel - 73.06 thousand m^2/ha. The highest photosynthetic potential was in the Kestrel variety with foliar fertilization ADOB macro+micro compatible with fungicide Impact (2.37 million m^2 × days/ha), slightly less than this value was noted in the variant with the application of fungicide Topsin M - 2.31 million m^2 × days/ha, respectively. Application of foliar fertilizer ADOB macro+micro with application rate of 2.0 kg/ha and fungicide Impact with application rate of 0.25 l/ha provides the highest weight of Harold root crops for the harvesting period at 413.0 g and Kestrel - 516.1 g, respectively.

The highest yield was observed in the variant with the application of complex microfertilizer ADOB macro+micro with the fungicides Topsin M and Impact, while it was in the variety Harold - 62.0-62.2 t/ha and Kestrel - 75.4-77.4 t/ha, the increase compared to the control was in the Harold variety - 20.4% and the Kestrel variety - 21.7%. Root crop yields were slightly lower when using Avangard P Beet fertilizers, Intermag-beet and Sani Mix in combination with fungicides, namely 55.50-60.10 t/ha in the Harold variety and 70.30-73.20 t/ha in the variety Kestrel. The variance analysis of the obtained data shows that on average, in 2015-2017, varietal features (A), whose share was 76.2%, foliar fertilization (B) - 10,1, the introduction of fungicides (C) - 6.8%, had the greatest influence on the formation of root beet productivity. The highest content of solids content and sugars was also observed in the variant, where foliar fertilizers ADOB macro+micro were additionally applied together with the fungicides Impact and Topsin M in the Harold variety - 15.6-15.7% and 8.5%, in the Kestrel variety - 16.0-16.1% and 8.9%.

In the beet of the Kestrel variety, the combined application of ADOB microfertilizers macro+micro and fungicide Impact allowed to obtain maximum rates of profitability - 241.6%, when applying micro fertilizers Sani Mix with fungicide Impact - 241.1%, in the Harold variety in variants ADOB microfertilizers macro+micro and with the use of Impact and Topsin M fungicides - 182.3% and 180.6%, respectively. Thus, the use of complex microfertilizers in combination with fungicides will not only increase the yield, but also improve the biochemical quality of beet root and increase the profitability of their production. Further study and improvement should focus on the in-depth study of foliar fertilization by microfertilizers on beet crops, in combination with growth regulators and biologicals, and their impact on the development and formation of plant productivity during ontogeny.

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