Study of the effect of foliar dressing on horseradish yield in the conditions of the North-Western part of Russia in Pskov region

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Abstract. The article presents an analysis of the problems in growing horseradish in the Russian Federation which are associated with an insufficient amount of planting material, as well as with the lack of cultivation technologies and not fully studied biological features of this crop. The results of the study contain material on the study of the effect of foliar dressing with Basfoliar complex mineral fertilizer in concentrations of 1.5 and 2.5 ml/l, 2.5 and 3.5 ml/l and 3.5 and 4.5 ml/l on horseradish yield in Pskov region. The experiments were conducted in the State Agricultural Academy of Velikie Luki and at the experimental plot in Pskov region, Pustoshkinskiy district in Orekhovo village. The paper presents data on improving the technology of growing horseradish of the Uvarovsky variety. The optimal concentrations of the applied Basfoliar fertilizer on the morphological parameters of the Uvarovsky variety in concentrations of 2.5 and 3.5 ml/l were established, thus, the maximum length of the leaf blade was 60.6 cm, the length of the rhizome — 37.8 cm. The highest commercial yield — 14.5 mt/ha and annual rhizomes — 10.0 mt/ha was obtained using Basfoliar 2.5 and 3.5 ml/l. To obtain a consistently high horseradish yield, it is necessary to provide plants with a balanced mineral nutrition throughout the vegetation period. Therefore, it is necessary to study in detail when choosing specific drugs and their effect on both morphological parameters and the structure of the crop. The results obtained during this work can be used for cultivation in order to increase the crop productivity in all horseradish farms.

1 Introduction

Horseradish (Latin*Armoracia rusticana*) is a perennial herbaceous plant belonging to the Cruciferous family. It has certain taste and useful (phytoncidal and medicinal) properties, therefore, horseradish is widely used in cooking and medicine. The rhizome juice is rich in mineral composition, it contains vitamins, mineral salts, and also contains lysozyme, which has antimicrobial activity [1-3].

The area of its growth is huge, this culture feels good on almost all continents. To date, horseradish is in demand as a vegetable crop [3, 4].

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Despite its unpretentiousness, not everyone gets a high-quality commodity root. Good quality rhizomes can be obtained only with knowledge of the biological features of the crop and the subtleties of cultivation technology [5, 6]. And it is also necessary to grow it on loose light loamy and sandy loam, fertile soils with a high content of humus. Otherwise, the rhizomes will have a bitter taste and bony texture. The primary reason that prevents the full cultivation of horseradish in Russia is not fully studied cultivation technology [7-10].

Throughout the vegetation period, horseradish is demanding of mineral nutrition, so nitrogen contributes to the formation of the leaf apparatus throughout the entire period of growth, if there is the lack of it, then the growth of leaves slows down, they turn yellow, and then die. Due to potassium, sugar accumulates, and its lack leads to leaf corrugation and weak venation [9]. Phosphorus is an element that promotes the growth of rhizomes mainly in the initial phase of growth and the development of a well-formed root system. In order to provide a full-fledged mineral nutrition for horseradish, it is a prerequisite to use mineral fertilizers in the form of foliar dressing throughout the vegetation period [11].

This type of dressing has advantages along with fertilizers that enter directly into the soil. Nutrients when sprayed fall on the leaf blade and penetrate the plant faster, and then transferred to the roots. As a result, the greatest effect of their assimilation is achieved, which contributes to an increase in yield. With an increase in yield, there is a significant removal of nutrients by plants from the soil, as a result of which the role of trace elements increases [12].

2 Materials and methods

The research was carried out from 2022–2023 in the State Agricultural Academy of Velikie Luki and in Pskov region, Pustoshkinskiy district in Orekhovo village.

The work objective: to study the effect of foliar dressing with complex mineral fertilizer Basfoliar on the productivity of horseradish in conditions of the North-Western part of Russia in Pskov region.

The object of the study was the Uvarovsky variety.

The experiment was carried out according to the scheme 70x35 cm at an angle of 45^{o} on the ridges with cuttings 15-18 cm long, the diameter of the cuttings 0.5-1.5 cm. The area of the working plot was 12.6 m^2, the repetition is 4-fold. The planting of horseradish cuttings was carried out manually in the third ten-day period of April 2022. The crop was grown as an annual crop during spring harvesting before the beginning of the growing season. During harvesting, the total and commercial yield, as well as annual rhizomes and root residues were determined.

The soil of the experimental site was sod-podzolic, medium loamy. The main agrochemical indicators of the arable soil layer of the experimental site: pH — 6.0–6.5, humus content — 2.3–2.5%, phosphorus — 240–300 mg/kg, potassium — 260–320 mg/kg of soil.

Meteorological conditions of the vegetation period of Pskov region were moderately warm, the amount of precipitation was close to the average annual data. The norm of the average monthly temperature was 18.4 °C. As a result, it can be said that the climatic conditions of the research work were typical for this area with minor differences in one period or another but optimal for growing the crop under study.

Foliar dressings with a liquid complex mineral fertilizer Basfoliar were carried out on vegetating horseradish plants. When using it, the growth processes of both shoots and roots are stimulated and it also helps to strengthen the immune system of plants. Due to the extract of Ecklonia maxima seaweed, a biostimulating effect occurs. The composition of this type of fertilizer includes a full complex of substances that are necessary for a full and balanced nutrition of the studied crop [13].

The first dressing was carried out 10 days after the emergence of seedlings, the second after 20 days and the amount of fertilizers was increased according to the scheme of the experiment.

Table 1. Field experiment design.

Variety	Spraying option	Concentration ml/l	
		1st dressing	2nd dressing
Uvarovsky	Control (without fertilizers)	0	0
	Basfoliar	1.5	2.5
	Basfoliar	2.5	3.5
	Basfoliar	3.5	4.5

The research was carried out according to the methodology of field experiment in vegetable growing in 2011 [14].

3 Results

As a result of our studies of foliar dressing with complex mineral fertilizer Basfoliar during the cultivation of spring annual horseradish crop of the ordinary variety Uvarovsky, its positive effect on the morphological parameters of plants was observed.

Thus, in terms of bush height, the highest indicator — 82.3 cm was noted with the use of mineral fertilizer Bosfoliar in the third option, the increase in height was 8.8 cm compared to the control option where horseradish bushes were the shortest and were equal to 73.5 cm.

The use of fertilizer in concentrations of 2.5–3.5 ml/l had a positive effect on the formation of the number of leaves, and amounted to 13.4 pcs./plant, a good result was noted in the fourth variant — 11.7 pcs./ plant. The minimum number of leaves is 8.5 pcs./plant was obtained in the control option (see Table 2).

Table 2. The effect of foliar dressing with Basfoliar complex mineral fertilizer on the morphological parameters of horseradish plants of the Uvarovsky variety.

Option	Concentration ml/l	Bush height, cm	Number of leaves, pcs./plant	Leaf blade length, cm	Leaf blade width, cm	Rhizome length, cm
1.	Control (without fertilizers) 0	73.5	8.5	53.3	24.9	29.2
2.	Basfoliar 1.5; 2.5	76.2	9.6	55.5	27.3	33.6
3.	Basfoliar 2.5; 3.5	82.3	13.4	60.6	27.8	37.8
4.	Basfoliar 3.5; 4.5	80.9	11.7	57.4	25.5	35.5

The largest length — 60.6 cm of the leaf blade was noted in the third option, and the smallest — 53.3 cm in the option without fertilizers.

The difference in the leaf blade width in all options was insignificant within 3 cm. Wider leaf blades were in the third — 27.8 cm and in the second — 27.3 cm options.

The use of foliar dressing with Bosfoliar in concentrations of 2.5 and 3.5 ml/l has a positive effect on the growth and development of the rhizome, which is an important

indicator for this crop, since it is this very part of the plant that is used in industrial processing and harvesting of planting material.

Table 3 presents the results of a study of the total yield of this crop and how foliar dressing affects the formation of annual rhizomes, root residues, and commercial yield separately.

Table 3. Horseradish yield of the Uvarovsky ordinary variety depending on the application of the complex mineral fertilizer Basfoliar (spring annual crop).

Option concentration, ml/l	**Yield of rhizomes, mt/ha**											
	commercial	increase		annual rhizomes	increase		root residues	increase		total	increase	
		mt/ha	%		mt/ha	%		mt/ha	%		mt/ha	%
Control (without fertilizers) 0	22.7	-	-	10.3	-	-	9.0	-	-	42	-	-
Basfoliar 1.5; 2.5	25.0	2.3	10.1	11.2	0.9	8.7	9.1	0.1	1.1	45.3	3.3	7.8
Basfoliar 2.5; 3.5	32.5	9.8	43.2	14.0	3.7	35.9	9.3	0.3	3.3	55.8	13.8	32.9
Basfoliar 3.5; 4.5	30.1	7.4	32.6	13.8	3.5	33.9	12.9	3.9	43.3	56.8	14.8	35.2

From the data analysis, it was found that an increase in commercial yield was observed in all options compared to the control group. The largest increase of 9.8 mt/ha was noted in the option with the use of Basfoliar in concentrations of 2.5 and 3.5 ml/l, which is 43.2% more than the control group.

The yield of annual rhizomes — 14.0 mt/ha was positively affected by spraying with the drug at the same concentration of 2.5 and 3.5 ml/l, in the option with the use of Basfoliar 3.5 and 4.5 ml/l, a good result of 13.8 mt/ha was obtained as well.

An increase in the concentration of the complex mineral fertilizer used by us contributed to a greater formation of root residues. Most of all — 12.9 mt/ha of them were obtained in the fourth option, which is 43.3% more than the control option. This is a significant increase in comparison with the previous two options where the increase was 1.5; 2.5 ml/l — 1.1%, 2.5; 3.5 ml/l — 3.3% with the use of the drug concentration. As a result, the highest total yield of the Uvarovsky variety was obtained when using Bosfoliar at a concentration of 3.5; 4.5 ml/l and was equal to 56.8 mt/ha, this is due to an increase in root residues that are not suitable for further use either for commercial purposes or for planting material.

4 Discussion

The efficiency of seed production of horseradish of the ordinary variety Uvarovsky in the conditions of Pskov region of the North-Western part of Russia can be achieved due to a balanced mineral nutrition. The use of foliar dressing has a positive effect on increasing the commercial yield and annual horseradish rhizomes, as well as increasing resistance to adverse weather factors such as cold, frost, drought and pest invasion.

5 Conclusion

According to the results of our research on improving the technology of growing horseradish by using the complex mineral fertilizer Basfoliar in different concentrations twice during the growing season in the conditions of the North-Western part of Russia, the most optimal concentration of this fertilizer has been established. A positive effect on the morphological parameters of the Uvarovsky variety was provided by fertilizing with a preparation in concentrations of 2.5 and 3.5 ml/l, therefore, the maximum length of the leaf blade was 60.6 cm, the rhizome length was 37.8 cm. The highest commercial yield — 14.5 mt/ha and annual rhizomes — 14.0 mt/ha was obtained using Basfoliar 2.5 and 3.5 ml/l.

The results obtained after this work can be applied to increase the productivity of this crop.

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