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RESEARCH ARTICLE

Approaches to control of winter rapeseed wintering

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Abstract

The spread of winter rapeseed in the north-eastern Forest-Steppe zone of Ukraine is prevented by unstable level of crop overwintering. To solve this problem, it is necessary to find effective methods of preparing plants for overwintering. The working hypothesis of research was the assumption of relationship between the intensity of blocking growth processes, sugars concentration, and level of rapeseed overwintering. We investigated variants of growth-regulating fungicides and their mixtures with complex fertilizer and retardant. Results of field experiment confirmed the dependence between level of sugar concentration and the level of wintering of rapeseed crop in variants with use of growth regulating fungicides and their mixtures with complex fertilizer. In the variants of crop treatment with mixtures of growth-regulating fungicides and retardants, the dependence has not been confirmed.

Keywords: Winter rape, Sugar content, Growth regulating fungicides, Overwintering

Introduction

Winter rapeseed is an important and economically attractive crop used for human consumption, biodiesel production and animal feed. Pullens et al. (2019) and Mihaylov (2024) emphasize the lack of yields stability, especially in regions with unfavorable wintering conditions. In Ukraine, climate warming is contributing to the expansion of crop cultivation areas to the north and east (Zabarna, 2020; Hryhoriv et al., 2024). The North-eastern Forest-Steppe of Ukraine is the coldest part of the country. Vegetation conditions need optimization of production processes to increase the level of plant winter hardiness. The fungicides application is a successful practice due to its effect on plant growth, chemical composition and wintering (Bakhmat & Sendetskiy, 2020 Kolisnyk et al., 2020; Karpenko et al., 2021). Additional factor of increasing winter hardiness is foliar nutrition, it helps plant overcome the critical period. (Jarecki et al., 2019; Sikorska et al., 2022). The working hypothesis of our study was the assumption of direct interconnecrion between the intensity of blocking growth processes, the sugar concentration in upper part of root, and influence of these factors on the level of crop overwintering.

Materials and Methods

The research was carried out in 2019-2022 (North-eastern Forest-Steppe of Ukraine). The objects of the research were variety (Chornyi Veleten) and hybrid (Parker) of winter rapeseed. In experiments the basic cultivation technology was used: predecessor – spring barley; sowing date – August 15–18; sowing depth – 3.5 cm, row spacing – 15 cm, seeding rate: for the variety – 0.8 million ha⁻¹, for hybrid – 0.7 million/ha. In the BBCH phase, 12–14 plants were treated with growth-regulating fungicides (and their tank mixtures) according to the scheme (Tab. 1).

Table 1. **Experimental design: Evaluation of the effect of growth regulators and complex fertilizers on the sugar content and overwintering of winter rapeseed.**

Variants variety / hybrid (Factor A)	Fungicides, growth regulator and fertilizer (autumn application) (Factor B)
1. Chornyi Veleten – variety. 2. Parker – hybrid.	1. No treatment (control). 2. Folicur, 1.0 l ha^{-1}. 3. Folicur, 1.0 l ha^{-1}+Wuxal Boron 2.0 l ha^{-1}. 4. Folicur, 1.0 l ha^{-1}+Chlormequat 1.5 l ha^{-1}. 5. Caramba, 1.25 l ha^{-1}. 6. Caramba, 1.25 l ha^{-1}+Wuxal Boron 2.0 l ha^{-1}. 7. Caramba, 1.25 l ha^{-1}+Chlormequat 1.5 l ha^{-1}.

The area of the accounting plot was 15 m^2. The experiment was repeated four times. Plants were selected for analysis after the end of the autumn vegetation. The sugar content in the rosette part was determined by the accelerated Bertrand method. The level of overwintering was determined in 14 days after the resumption of spring vegetation. Statistical data processing was performed on the basis of the Statistica 6.0 software (StatSoft, Tulsa, USA). Weather conditions in 2019-2022 were similar to the average long-term ones with a steady warming trend. This affected the shift in the end of autumn vegetation and the earlier start of the spring vegetation period. The most favorable conditions for overwintering were in 2019-2020. The conditions in 2020-2021 were less optimal.

Results and Discussion

Successful overwintering of rapeseed depends on the conditions of autumn vegetation. During this period, plants go through the phases of germination, shoots and rosettes. An important indicator of the level of autumn development of winter rapeseed crops is the mass of the above-ground part of plants per 1 m^2. On average, the mass of plants in the control was 1956.0 g/m2, varying from 2016.0 g for the Chornyi Veleten variety to 1898.0 g for the Parker hybrid (Tab. 2). The use of growth-regulating fungicides reduced the indicator from 1956.0 to 1725.6 g (by 11.8%). The greatest effect was recorded on the variants with Folicur: phytomass decreased by 265.0 g (13.5%). The addition of Wuxal Boron fertilizer was accompanied by a decrease in the intensity of blocking growth processes and some growth in phytomass. This is consistent with the studies of Gugała et al. (2019), where foliar fertilization increased the leaves number and root diameter. Similar results were obtained by Jankowski et al. (2016) and Jarecki et al. (2019).

Table 2. **Dynamics of crop above-ground phytomass of winter rapeseed (2019-2021).**

Variant of treatment (Factor B)	Variety / hybrid (Factor A)		Average	
	Chornyi Veleten	Parker	X	± to control
No treatment (control)	2016	1896	1956	-
Folicur	1713.6	1668.5	1691	-265
Folicur+Wuxal Boron	1723.7	1659	1691.3	-264.7
Folicur+Chlormequat	1429.5	1388.6	1409.1	-547
Caramba	1806.3	1714	1760.2	-195.8
Caramba+Wuxal Boron	1836.6	1723.5	1780	-176
Caramba+Chlormequat	1601.2	1598.3	1599.8	-356.2
Duncan's test$_{0.05}$ A-22.8; B-34.2; AB-56.6				
Average for the scheme				
Fungicide, separately	1760	1691.2	1725.6	-230.4

Fungicide+Wuxal Boron	1780.1	1691.2	1735.7	-220.32
Fungicide+Chlormequat	1515.4	1493.5	1504.4	-451.59

The use of growth-regulating fungicides was accompanied by decrease in the above-ground phytomass index, which did not exceed 15%. The difference between the average value of the phytomass index in the control and the Fungicide+Chlormequat variant was minus 451.6 g (23.1%). The effect of adding Chlormequat was most pronounced in the Folicur+Chlormequat variant, where the decrease in the phytomass was 547.0 g or 28.0%. The high level of growth blocking in this variant led to leveling of the varietal difference in phytomass indicators.

Blocking the rape growth after plant treatment has a complex effect, consisting in changes of vegetative development and sugar content in the wintering organs (Hosseini et al., 2023; Ahmadi & Eyni-Nargeseh, 2023). These changes are considered as factors increasing the resistance of crops to adverse conditions of the winter-spring period. (Gugała et al., 2019). The main factor of variability in the sugar content was the difference in the duration and intensity of growth processes the, the crop genotypes had a lesser effect. All variants of the experiment had higher indicators of the sugar content. The average sugar content was: 22.2% for the separate fungicide, 23.4 and 24.7% for the Fungicide+Wuxal Boron and Fungicide+Chlormequat schemes, respectively (Tab. 3). The increase of sugar content was + 2.7% due to the use of growth-regulating fungicides and + 3.9 and + 5.11% due to the use of mixture with fertilizer and retardant. The increase in sugar content was + 2.7% due to the use of growth-regulating fungicides, and + 3.9% and + 5.11% using mixtures with fertilizer and retardant.

Table 3. Dynamics of sugar content in winter rapeseed plants, % (2019-2021).

Variant of treatment (Factor B)	**Variety / hybrid (Factor A)**		**Average**	
	Chornyi Veleten	**Parker**	***X***	**± to control**
No treatment (control)	18.7	20.3	19.5	
Folicur	22.9	23.4	23.15	3.65
Folicur+Wuxal Boron	23.3	24.5	23.9	4.4
Folicur+Chlormequat	22.2	26.1	24.15	4.65
Caramba	19.8	22.6	21.2	1.7
Caramba+Wuxal Boron	20.4	25.6	23	3.5
Caramba+Chlormequat	25.5	24.9	25.2	5.7
Duncan's test$_{0.05}$ A-2.0; B-3.7; AB-5.5				
Average for the scheme				
Fungicide, separately	21.35	23	22.18	2.68
Fungicide+Wuxal Boron	21.85	25.05	23.45	3.95
Fungicide+Chlormequat	23.85	25.5	24.68	5.18

The data confirm that blocking of growth processes due to the use of growth-regulating fungicides was accompanied by increase in the sugar concentration in the rosette part of plants. Wuxal Boron and Chlormequat provided a similar effect. Most researchers note a close correlation between the sugar content in vegetative organs of plants with the development cycle and the level of overwintering. It is the sugar concentration determines the resistance of cell cytoplasm to freezing. (Gavelienė et al., 2018; Bakhmat & Sendetskiy, 2020).

The average value of overwintering rate in the crop was 64.5% (Tab. 4). The highest level of plant survival was observed in 2020: 68.8%. The year of 2020-2021 was less favorable for overwintering, with an indicator of 59.4%. In the variants with seperate use of fungicides and in the variants with Wuxal Boron fertilizer, the level of overwintering increased to 69.7% and 72.5%, respectively. Thus, the increase in the sugar concentration in winter rapeseed plants, caused by a decrease in the intensity of growth processes due to the use of growth-regulating fungicides (and fertilizers), ensured an improvement in the level of winter hardiness of crops. In variant with Fungicide+Chlormequat reduction in plant phytomass, ensured a high level of sugar accumulation, was not accompanied by an improvement in the overwintering level indicator. The indicator value of plant number that restored spring vegetation did not correlate with the sugar content values at the beginning of overwintering and were statistically lower than the indicators in the Fungicide, separately and Fungicide+Wuxal Boron variants.

Table 4. Overwintering indicators of winter rape crop, % (2020-2022).

Variant of treatment (Factor B)	Variety / hybrid (Factor A)			
	Chornyi Veleten	Parker	Average X	± to control
No treatment (control)	59.7	57.8	58.8	
Folicur	69.7	68.4	69	10.2
Folicur+Wuxal Boron	72.4	71.3	71.9	13.1
Folicur+Chlormequat	61.5	58.7	60.1	1.3
Caramba	71.5	69.4	70.4	11.6
Caramba+Wuxal Boron	73.3	72.8	73.1	14.3
Caramba+Chlormequat	62.5	58.1	60.3	1.5
Duncan's test$_{0.05}$ A-2.0; B-3.7; AB-5.5				
Average for the scheme				
Fungicide, separately	70.6	68.9	69.7	10.9
Fungicide+Wuxal Boron	72.8	72.1	72.5	13.7
Fungicide+Chlormequat	62	58.4	60.2	1.4

Conclusions

Blocking growth processes using growth regulating fungicides and in mixtures with Vuksal Boron fertilizer is the most effective method of autumn preparation of winter rape crops. Method provides a sufficient level of sugar accumulation and satisfactory results of overwintering in the north-eastern Forest-Steppe zone of Ukraine. The difference in sugar content in the rosette zone of plants at the beginning of overwintering indicates the level of potential winter hardiness. The difference in sugar concentration indicators due to changes in autumn plant development with treatment of Fungicide + Chlormequat cannot be considered as a factor of increasing winter hardiness. Assessment of the potential level of winter hardiness of crops in this case requires the use of other parameters and additional study.

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