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INFLUENCE OF NITROGEN AND SULPHUR FERTILIZATION ON DISEASES OF WINTER OILSEED RAPE

Summary

The aim of field experiments was to evaluate the influence of nitrogen–sulphur fertilization on healthiness of winter oilseed rape cultivar Nelson. It was found that the occurence of fungal diseases on oilseed rape was dependent on sulphur and nitrogen fertilization. Nitrogen fertilization increased the incidence of diseases. The plant fertilized with sulphur showed lower fungal disease infection. Sulphur fertilizers decreased the infection by the following pathogens: Peronospora parasitica, Erysiphe cruciferarum, Verticillium dahliae.

***Key words**: oilseed rape, disease, fertilization, nitrogen, sulphur*

WPŁYW NAWOŻENIA AZOTEM I SIARKĄ NA WYSTĘPOWANIE CHORÓB RZEPAKU OZIMEGO

Streszczenie

Celem pracy było określenie wpływu nawożenia azotem i siarką na występowanie chorób rzepaku ozimego odmiany Nelson. Na podstawie doświadczenia polowego stwierdzono, że nawożenie azotem zwiększało występowanie chorób grzybowych rzepaku ozimego. Natomiast nawożenie siarką wpływało na mniejsze porażenie roślin przez następujące patogeny: Peronospora parasitica, Verticillium dahliae. Jednak warunki pogodowe (duża ilość opadów) wpływały na obniżenie zdrowotności roślin.

***Słowa kluczowe**: rzepak, choroby, nawożenie, azot, siarka*

1. Introduction

Diseases which cause a substantial decrease in the quantity and quality of the crop reaching even 10–60% may occur on winter oilseed rape during the whole vegetation period [2, 24]. Currently, chemical protection using fungicides is the most widely used method to reduce the harmfulness of the diseases [16]. In addition to chemical treatments, fertilization may profitably affect the plants health status [15, 26]. Nitrogen, which physiological and yield-forming effect on the plant is dominant, influences plant health in a differentiated manner. Usually, an overall increase in nitrogen content in the plant increases plants susceptibility to infestation by pathogens [6, 11]. On the other hand, sulfur fertilizer stimulates an immunity of oilseed rape to attack of diseases and pests [4, 7, 13, 18, 20].

The aim of the study was to determine an effect of nitrogen and sulfur fertilization on diseases occurrence in winter oilseed rape of Nelson variety.

2. Materials and methods

Granular fertilizer Vigor S, being the source of sulfur, contained 90% of sulfur and 10% of bentonite produced by

The experiment was established in the years 2009–2010 using randomized block design with 4 replications, on good wheat complex soil in the long-term field experiments of the Institute of Crop Production, University of Agriculture in Krakow-Prusy. Winter oilseed rape of Nelson Nelson variety was presown and fertilized with NPK at a dose of pure component: 28/103/270 [kg/ha] in the form of [kg/ha]: 100 superfoska [4% N (N-NH_4, -NH_2), 17% P (P_2O_5), 28% K (K_2O)], 211 triple superphosphate [41% P (P_2O_5)], 490 potassium salt (60% K_2O), and 70 ammonium nitrate (17% N-NH_4, 17% -NH_2). Fertilization with nitrogen was carried out at two different times: before the onset of spring growth, three weeks after the application of the first nitrogen dose in growth phase stem elongation (BBCH 30–39). Nitrogen fertilization as top dressing was made with ammonium nitrate. Granular fertilizer Vigor S, being the source of sulfur, contained 90% of sulfur and 10% of bentonite produced by Chemical Plant Siarkopol Tarnobrzeg. Sulfur fertilization was made in growth stage of canola plants: inflorescence emergence (BBCH 50–59). The following combinations of nitrogen and sulfur doses were used in the experiment [kg/ha]: I – without fertilization; II – 100 N+0 S; III – 0 N+70 S; IV – 100 N+70 S; V – 250 N+0 S; VI – 250 N+70 S. The plants were protected from agrophages according to the standard variant of protection using the following agents: herbicides – Butisan 500 SC (2.5 l/ha), Fusilade Forte 150 EC (1.5 l/ha); insecticides – Nurelle D 550 EC (0.6 l/ha), Mospilan 20 SP (0.12 l/ha), Decis 2.5 EC (0.2 l/ha in the year 2009), Talstar 100 EC (0.1 l/ha in 2010); fungicides – Caramba 60 SL (0.7 l/ha), Pictor 400 SC (0.3 l/ha).

The study period was characterized by high variability in terms of the distribution of temperature and precipitation (Table 1). The temperature in vegetation period 2009-2010 did not differ from the multiannual average. In contrast, the amount of rainfall was very varied. Very little rainfall was recorded in April 2009. On the other hand, the average rainfall in May and June 2009 and 2010 was even 3 times higher than the average for many years. Particularly most of rainfalls was in May 2010.

Evaluation of the health state of oilseed rape was performed at the beginning of plants maturation in the stage BBCH 80–82. The study included randomly selected samples of 25 plants from each plot, and their infection by fungi was determined according to the scale: 0° – no symptoms, 4° – more than 50% of the area covered by lesions [5]. Then the infection index [%] was calculated on the basis of the observations [23]. Pathogens were identified on aqueous preparations, which were viewed under a microscope. After finding the spores, the cause of stains was determined, and the identification was confirmed using the appropriate keys [1, 14].

The results were analyzed statistically using analysis of variance and Duncan test, with significance level of p=0.05.

3. Results and discussion

The symptoms of diseases such as dry rot, dark pod spot, downy mildew, powdery mildew and verticillium wilt were reported on winter oilseed rape of Nelson variety (Table 2, 3). Evaluation of the results showed that different doses of nitrogen and sulfur fertilization affected plants infestation by pathogenic fungi. It was found that nitrogen fertilization increased the incidence of diseases: dry rot, dark pod spot. Sulfur fertilization decreased oilseed rape infestation by the fungi causing downy mildew and verticillium wilt. In 2010, no significant differences were found between sulfur-fertilized objects (Table 3). The impact on disease occurrence in 2010 could have had a very high rainfall in May and June.

It was found that nitrogen fertilization in dose 250 kg/ha significantly increased yield of winter oilseed rape (Table 2, 3). The highest yield was obtained in 2009 in object fertilized nitrogen 250 kg/ha without sulfur. Sulfur fertilization did not affect significantly on yield.

It is pointed out, that overall increase in nitrogen content in the plant usually increases its susceptibility to infestation by pathogenic fungi. Nitrogen fertilization stimulates the growth of plants, which increases the ratio of young to old leaves. Higher concentration of amino acids and lower activity of enzymes metabolizing phenols is noted in the plants well fertilized with nitrogen. This causes that plants fertilized with high doses of nitrogen are more strongly attacked by pathogens and pests, and also have weaker defense mechanisms [9]. It was observed that the increase in nitrogen dose affects the higher incidence of powdery mildew, downy mildew, dark leaf spot, blossom rot and gray mold [5, 11, 19, 20].

Sulfur is a mineral that exhibits protective effect in case of plants exposure to biotic (pests and diseases) and abiotic stressors (drought, low temperature). Under conditions of well nourishment with sulfur, the plant activates the mechanism of so-called sulfur induced resistance (SIR) in response to the pathogen [10, 22, 25].

Table 1. Weather conditions in vegetation seasons
Tab. 1. Warunki pogodowe w sezonach wegetacyjnych

Weather conditions	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
monthly average temperatures [^{O}C] in years / *miesięczne średnie temperatury [^{O}C] w latach*												
2008	–	–	–	–	–	–	–	18.25	12.8	10.7	4.98	1.12
2009	–3.4	–1.1	2.7	11.4	13.6	16.2	20.2	18.8	15.4	7.7	4.7	–1.0
2010	–6.3	–2.2	3.1	9.1	13.1	17.6	20.8	–	–	–	–	–
1985–2010	–0.2	1.1	3.8	8.3	13.9	17.5	18.6	18.2	13.1	9.9	3.9	0.2
monthly average precipitation [mm] in years / *miesięczne średnie ilości opadów [mm] w latach*												
2008	–	–	–	–	–	–	–	44.1	111.3	50.05	24.3	40.39
2009	27.69	30.86	75.83	3.56	99.6	163.4	71.67	66.7	39.8	82.03	71.11	41.68
2010	44.2	31.5	31.0	39.9	299.0	135.1	105.2	–	–	–	–	–
1985–2010	27.5	19.0	53.5	42.6	46.4	52.9	108.0	61.8	87.8	49.2	32.6	41.1

Source: own work / Źródło: opracowanie własne

Table 2. Infection and yield in the year 2009 winter oilseed rape cv. Nelson by pathogenic fungi depending on differentiated fertilization with nitrogen and sulphur
Tab. 2. Porażenie przez grzyby pasożytnicze i plon rzepaku ozimego odmiany Nelson w 2009 roku w zależności od nawożenia azotem i siarką

Diseases	Infection index [%]						
	Fertilization with nitrogen and sulphur [kg/ha]						
	without S			70 S			Standard deviation Sd
	0 N	100 N	250 N	0 N	100 N	250 N	
Dry rot *Leptosphaeria* spp. *Sucha zgnilizna*	1.7 a-d	4.2 b-g	5.0 d-h	2.5 a-e	1.7 a-d	5.8 e-h	1.92
Dark pod spot *Alternaria* spp. *Czerń krzyżowych*	1.7 a-d	5.8 e-h	4.2 b-g	4.2 b-g	3.3 a-f	5.8 e-h	2.36
Downy mildew *Peronospora parasitica* *Mączniak rzekomy*	4.2 b-g	6.7 fgh	2.5 a-e	3.3 a-f	1.7 a-d	1.7 a-d	1.08
Powdery mildew *Erysiphe cruciferarum* *Mączniak prawdziwy*	5.8 e-h	6.7 fgh	7.5 gh	5.0 d-h	6.7 fgh	5.0 d-h	2.36
Verticillium wilt *Verticillium dahliae* *Werticilioza*	7.5 gh	8.3 h	6.7 fgh	5.8 e-h	6.7 fgh	4.2 b-g	1.98
Yield [t/ha] *Plon*	1.12 a	2.02 ab	4.44 c	1.65 a	2.99 abc	3.73 bc	0.85

Means for diseases and yield marked by the same letter are not statistically different according to Duncan's test (p = 0.05)
Średnie dla chorób i plonu oznaczone tymi samymi literami nie różnią się istotnie według testu Duncana (p = 0.05)

Source: own work / Źródło: opracowanie własne

Table 3. Infection and yield in the year 2010 winter oilseed rape cv. Nelson by pathogenic fungi depending on differentiated fertilization with nitrogen and sulphur

Tab. 3. Porażenie przez grzyby pasożytnicze i plon rzepaku ozimego odmiany Nelson w 2010 roku w zależności od nawożenia azotem i siarką

Diseases	Infection index [%]						
	Fertilization with nitrogen and sulphur [kg/ha]						
	without S			70 S			Standard deviation Sd
	0 N	100 N	250 N	0 N	100 N	250 N	
Dry rot *Leptosphaeria* spp. *Sucha zgnilizna*	0.7 ab	0.0 a	0.0 a	2.3 a-e	3.3 a-f	0.0 a	1.60
Dark pod spot *Alternaria* spp. *Czerń krzyżowych*	3.7 a-f	2.3 a-e	2.7 a-e	2.3 a-e	2.7 a-e	2.3 a-e	1.37
Downy mildew *Peronospora parasitica* *Mączniak rzekomy*	0.7 ab	4.7 c-h	2.0 a-e	1.0 abc	4.0 b-g	1.3 a-d	1.60
Yield [t/ha] *Plon*	3.02 a	3.66 ab	3.80 b	2.99 a	3.96 b	3.57 ab	0.30

Means for diseases and yield marked by the same letter are not statistically different according to Duncan's test (p = 0.05)

Średnie dla chorób i plonu oznaczone tymi samymi literami nie różnią się istotnie według testu Duncana (p = 0.05)

Source: own work / Źródło: opracowanie własne

This mechanism involves an increase in the natural resistance of plants to infection by pathogens by mobilization of metabolic processes involving sulfur. This element plays an important role in biochemical defense reactions that are activated in the plant after the contact with pathogenic fungi. Sulfur is a part of a series of compounds such as H_2S, glutathione, sulfolipids, glucosinolates, phytoalexins, alliin. These compounds play an important role in increasing the resistance of plants to pathogens and environmental stress. The content of cysteine and methionine increases the resistant plant tissues. In turn, the infected plants, glutathione participates in the synthesis of phytoalexin or lignin reinforcing the cell walls. Phytoalexins hardly occur in normal tissues. However, they are synthesized in cells close to the site of infection. In cruciferous plants, phytoalexins have at least one sulfur atom and exhibit an antifungal activity. However, they show high effectiveness only with respect to weak pathogens. These compounds may limit infection, but they do not block completely the infestation [3, 7, 8, 21].

Also glucosinolates play an important role in ensuring the plants resistance to pests and diseases. Products of these compounds decomposition are characterized by a high biological activity. This is demonstrated in a significant toxicity to pathogenic fungi that are the cause of diseases such as dry rot, dark leaf spot and downy mildew. Glucosinolates affect a decrease in palatability and an increase in toxicity of the plant. As a result, they are less damaged by insects. This reduces the routes of infection and the risk of diseases spreading [10, 12, 17].

But sometimes, in spite of sulfur fertilization, a decrease in plant health status is noted. This may be due to the lack of this element availability for the plants. Sulfate sulfur is easily moved beyond the reach of the root system of plants, and considerable precipitation during the vegetation season contribute to the washing out of nutrients introduced before sowing, and delivered regularly during the vegetation [27]. The amount of precipitation in May and June in both vegetation seasons during the experiment exceeded the multiannual average.

The use of the fact that nitrogen and sulfur fertilization in rape seeds cultivation affects plant health status, makes it possible to reduce the amount of chemical products used in plant protection. Winter rape seeds chemically protected against diseases and simultaneously fertilized with sulfur usually exhibit lower infestation by the most dangerous pathogens compared to the plants protected only with fungicides. This is especially important due to the obligation of integrated plants protection application by all professional users of plant protection products [16].

4. Summary

In the study period the symptoms of diseases such as dry rot, dark pod spot, downy mildew, powdery mildew and verticillium wilt were reported on winter oilseed rape of Nelson variety. Nitrogen fertilization increased the incidence of oilseed rape diseases: dry rot, dark pod spot. Sulfur is a mineral that exhibits protective effect in case of plants exposure to diseases causing downy mildew and verticillium wilt. However, the weather conditions (high rainfall) affected plant health.

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