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CONDITION OF WINTER WHEAT IN PURE AND MIXED SOWING

Summary

The objective of the study was to evaluate the influence of sowing (pure, mixed double-and triple-species) on condition of ear, leaves and stem base of winter wheat of Ozon variety. The experiment was carried out in three replicates on a very good wheat soil complex. Based on the study it was found that during vegetation period, winter wheat was attacked by leaf blotch and glume blotch (Septoria nodorum), stem rust (Puccinia recondita), fusarium foot rot (Fusarium spp.). Sowing method significantly differentiated the intensity of incidence of fungal diseases. The tested variety of winter wheat in the pure sowing was characterized by the highest infestation by fungal diseases. In contrast, mixed triple-species sowing in which winter wheat constituted 25%, rye 50% and winter triticale 25% of sowing norm, significantly reduced the development of leaf blotch, glume blotch (S. nodorum) and fusarium foot rot (Fusarium spp.).
Keywords: *winter wheat, sowing methods, fungal diseases*

STAN ZDROWOTNY PSZENICY OZIMEJ W SIEWIE CZYSTYM I MIESZANYM

Streszczenie

Celem pracy była ocena wpływu sposobu siewu (siew czysty, mieszany dwugatunkowy i trójgatunkowy) na stan zdrowotny kłosa, liści oraz podstawy źdźbła pszenicy ozimej odmiany Ozon. Doświadczenie prowadzono w trzech powtórzeniach na glebie kompleksu pszennego bardzo dobrego. W oparciu o przeprowadzone badania stwierdzono, że w okresie wegetacji pszenica ozima była atakowana przez septoriozę liści i plew pszenicy (Septoria nodorum), rdzę brunatną (Puccinia recondita) oraz fuzaryjną zgorzel podstawy źdźbła i korzeni zbóż (Fusarium spp.). Sposób siewu istotnie różnicował nasilenie występowania chorób grzybowych. Testowana odmiana pszenicy ozimej w siewie czystym odznaczała się najwyższym porażeniem przez grzyby chorobotwórcze. Natomiast siew mieszany trójgatunkowy, w którym pszenica ozima stanowiła 25%, żyto 50%, a pszenżyto ozime 25% normy wysiewu, istotnie ograniczał rozwój septoriozy liści i plew (S. nodorum) oraz fuzaryjnej zgorzeli podstawy źdźbła (Fusarium spp.).
Słowa kluczowe*: pszenica ozima, sposób siewu, choroby grzybowe*

1. Introduction

Winter wheat compared to other cereals is very susceptible to infestation by fungal diseases [9]. The risk of infection increases when wheat is cultivated in monoculture and cereal crop rotation [13]. Development of fungal diseases in the vegetation period [21] reduces the yield, the mass of thousands of seeds, reduces the amount of gluten and protein, thus impairing the quality of grain. Considering current requirements for plant protection, especially the agrotechnical methods should constitute the basis in reducing the development of pests. This method falls into the scope of integrated protection. One method to reduce the development of diseases consists in using mixed sowing. Mixed sowing is a preventive treatment which aims at improving condition of plant species and introducing biodiversity. Biological diversity allows for improved usage of resources in the natural environment [6]. Between-species cereal mixtures ensure a slower spread of diseases and pests in the stand. Therefore they are increasingly being used as a biological fight against diseases and pests [4]. Moreover, the advantage of using cereal mixtures is that they increase the resistance of cereals to lodging [19] and reduce stand infestation [12, 15]. As a result, it is possible to reduce chemical protection of plants even with a high severity of the disease. In the literature, there is a large number of publications describing mixed sowing of spring cereals, mainly with barley and oat [10, 16, 17, 19]. However, studies on condition of winter wheat in mixed sowing are not numerous.

The objective of the study was to evaluate the condition of leaves, ear and the stem base of winter wheat of Ozon variety depending on the sowing method (pure, mixed double- and triple-species).

2. Materials and methods

Field studies were conducted in the years 2014-2016. The experiment was established on a very good wheat soil complex in the Agricultural Experimental Farm in Prusy near Cracow. In the experiment, the condition of Ozon wheat variety was compared in pure and mixed sowing. This variety belongs to the group of bread varieties and is characterized by good freeze resistance. The particular advantage of this variety consists in a very good resistance to powdery mildew and stem rust and intermediate resistance to leaf blotch and stem base diseases [3]. One-factor experiment was performed in three replicates.

Pea was a previous cropping for cereals. Cultivation and fertilization were consistent with agrotechnical requirements for this plant species. Sowing of tested plants was performed in III decade of September in a spacing between rows of 14 cm. Winter wheat (Ozon variety) in pure sowing was seeded in the amount of 205 kg·ha^{-1}, in mixed double-species in the amount of 102.50 kg·ha^{-1}, and in mixed triple-species in the amount of 51.25 kg·ha^{-1}. Winter triticale (Borowik variety) in mixed double-species was seeded at

93.90 kg·ha^{-1} and in mixed triple-species at 46.95 kg·ha^{-1}. Rye in turn (Amber variety), in mixed double-species constituted 33.80 kg·ha^{-1}, and in mixed triple-species 16.90 kg·ha^{-1}. Cultivation and fertilization were applied according to the agrotechnical recommendations for this plant species. During the growing season cereals were not protected against pests.

Winter wheat condition assessment was conducted using 25 randomly collected plants from each plot. At initial maturity of wheat grain (BBCH–73), the incidence of disease on leaves, ears and at the base of culm was assessed on a four–step scale where: 1 denotes a plant at good condition and 4 describes infestation ≥ 50% of the plant [2]. Condition of the tested plants was compared in the following combinations:

1. pure sowing of winter wheat,
2. mixed double-species sowing (winter wheat 50% sowing norm + rye 50% sowing norm),
3. mixed double-species sowing (winter wheat 50% sowing norm + winter triticale 50% sowing norm),
4. mixed triple-species sowing (winter wheat 25% sowing norm + rye 50% sowing norm + winter triticale 25% sowing norm),
5. mixed triple-species sowing (winter wheat 25% sowing norm + rye 25% sowing norm + winter triticale 50% sowing norm),
6. mixed triple-species sowing (winter wheat 50% sowing norm + rye 25% sowing norm + winter triticale 25% sowing norm).

Obtained results were presented in the form of infestation index (DI) according to Pierre and Regnault [14]. The calculated index of infestation (DI) was subject to analysis of variance, in which differences between mean values were compared using Tukey's test at $\alpha = 0.05$.

3. Results and discussion

Weather conditions during the study were different (Table 1). In 2015, from April to August only May was characterized by excessive humidity compared to the multiannual period. In the remaining months from spring to plant harvesting, shortage of precipitation and increase in air temperature in relation to the multiannual period, were observed. At the same period in 2016, excess of precipitation was reported in April and July. Thus, it can be concluded that 2015 was drier and warmer in comparison to 2016.

During vegetation, winter wheat was attacked by leaf blotch and glume blotch (*Septoria nodorum*), stem rust (*Puccinia recondita*), fusarium of ear and fusarium foot rot (Fusarium spp.). According to many authors [1, 6, 8, 9, 21] these diseases are typical for winter wheat.

Our own studies have shown that increase in the incidence of fungal diseases of winter wheat was dependent on the year of study. Weather conditions during the vegetation period of winter wheat in 2015 from April to August did not promote the development of fungal diseases (Table 1, 2). During this period, only a trend in the growth of stem rust (*P. recondita*) was observed. While the hydrothermal conditions in the same period in 2016 contributed to the growth in the development of fungal diseases, especially leaf blotch and glume blotch of wheat ear (*S. nodorum*), as well as fusarium foot rot (*Fusarium spp.*). According to the literature [5, 8] especially blotch develops in periods characterized by the presence of heavy rain.

Cereal mixtures, especially spring cereals, have been the subject of numerous studies. According to many authors [10, 11, 12, 15, 17, 19, 23] cereal mixtures compared to pure stand exhibit lesser susceptibility to diseases and pests and better utilize nutrients. In addition, they protect the arable lands against loss of organic matter in the soil and reduce lodging of cereals. Cereal mixtures increase tolerance to unfavorable habitat conditions and reduce "soil sickness" [17, 18].

Between-species mixtures of winter cereals are very rarely introduced into agricultural practice [7]. Our own study demonstrated that sowing method significantly differentiated the intensity of occurrence of leaf blotch and glume blotch (*S. nodorum*) and fusarium foot rot (Fusarium spp.) of winter wheat (Table 3). Winter wheat of Ozon variety in pure sowing was characterized by the highest infestation by fungal diseases. In turn, mixed sowing reduced winter wheat infestation by phytopathogenic fungi. Similar reaction was reported by Tratwal et al. [22] in mixed between-varieties sowing of winter wheat.

Table 1. Weather conditions during the study (according to the Meteorological Station in Prusy)
Tab. 1. Warunki pogodowe w okresie prowadzonych badań (według Stacji Meteorologicznej w Prusach)

Years	Months											
	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII
	Sum of precipitation (mm)											
2014/2015	98.2	38.0	15.2	9.0	5.6	19.8	33.2	19.4	102.6	56.6	71.8	41.8
2015/2016	69.4	51.4	53.8	9.4	21.2	80.6	34.6	58.6	41.40	59.8	92.8	62.0
1985-2014	73.5	43.6	33.6	30.09	32.1	23.6	33.5	49.1	70.2	79.2	89.3	81.5
	Temperature of air (°C)											
2014/2015	15.2	9.9	5.9	0.9	1.2	1.1	4.9	9.1	13.3	17.5	20.6	22.0
2015/2016	15.2	7.9	5.5	4.1	-2.1	3.9	4.7	9.5	14.5	18.8	19.5	18.5
1985-2014	16.8	8.7	3.3	-0.6	-2.1	-1.0	3.1	8.8	13.4	15.2	17.5	18.5

Source: own work / Źródło: opracowanie własne

Table 2. Infestation index (DI) of winter wheat by fungal diseases between 2015-2016
Tab. 2. Indeks porażenia (DI) pszenicy ozimej przez grzyby chorobotwórcze w latach 2015-2016

Years	Leaves diseases caused by:		Ears diseases caused by:		Fusarium foot rot
	S. nodorum	*P. recondita*	*S. nodorum*	Fusarium spp.	Fusarium spp.
2013	0.53	0.71	0.29	0.17	0.52
2014	2.92	0.86	1.28	0.29	1.16
$LSD_{0,05}$	0.74	n. s.	0.42	n. s.	0.32

n.s. – not significant difference *Source: own work / Źródło: opracowanie własne*

Table 3. Infestation index (DI) of winter wheat by fungal diseases depending on the sowing method
Tab. 3. Indeks porażenia (DI) pszenicy ozimej przez grzyby chorobotwórcze w zależności od sposobu siewu

Sowing method	Leaves' diseases		Ears' diseases		Fusarium foot rot
	Septoria nodorum	*Puccinia recondita*	*Septoria nodorum*	Fusarium spp.	Fusarium spp.
1.	2.22	0.72	1.47	0.27	0.85
2.	1.90	1.05	0.50	0.18	0.80
3.	1.77	0.99	1.06	0.30	1.03
4.	1.30	0.80	0.34	0.17	0.72
5.	1.72	0.60	0.50	0.25	0.85
6.	1.50	0.60	0.88	0.20	0.80
Mean	**1.73**	**0.79**	**0.79**	**0.23**	**0.84**
$LSD_{0,05}$	0.39	n. s.	0.41	n. s.	0.29

1-6 in methodology;- n.s. – not significant difference *Source: own work / Źródło: opracowanie własne*

The results of our own studies indicate that mixed sowing particularly reduced the development of leaf blotch and glume blotch of ear (*S. nodorum*) and fusarium foot rot (Fusarium spp.). The obtained results were also consistent with those reported by Michalski et al. [12] who also noticed a decrease in the intensity of leaf blotch and glume blotch of wheat ear and triticale in mixed sowing. Similarly, Kurowski et al. [10] confirmed positive effect of mixed sowing on phytosanitary status of plants. In the cereal mixture they found the strongest reduction in the development of fusarium foot rot.

In our own studies, in compared combinations it was found that mixed triple-species sowing in which winter wheat constituted only 25%, rye 50% and triticale 25% of sowing norm significantly reduced the development of leaf blotch, glume blotch (*S. nodorum*) and fusarium foot rot (Fusarium spp.). Similarly, Michalski et al. [12] observed an improvement in cereal condition with simultaneous decrease in its amount in the mixture. Tratwal et al. [22] in between-variety mixture consisting of three winter wheat varieties found a decrease in the frequency of incidence of *Blumeria graminis f.* sp. *tritici* compared to pure sowing.

In addition, in mixed sowing of wheat varieties, one reported an increase in yield compared to pure sowing [22]. In our own studies it was reported that the occurrence of stem rust (*P. recondita*) on winter wheat leaves was rare. However, double-species sowing supported the development of this disease. In turn, triple-species sowing has shown a trend to reduce the development of *P. recondita*. Similarly Tratwal [20] and Kurowski et al. [10] reported a decrease in the intensity of incidence of wheat yellow rust and *Puccinia hordei* in spring cereal mixtures.

4. Conclusion

Method of sowing significantly differentiated the intensity of incidence of leaf blotch and glume blotch (*Septoria nodorum*) as well as fusarium foot rot (Fusarium spp.) of winter wheat. Within the sowing methods under study, wheat cultivated in triple-species mixture found in the amount of 25% with 50% rye and 25% winter triticale, was characterized by a significant reduction in the development of leaf blotch and glume blotch of ear (*S. nodorum*) as well as fusarium foot rot (Fusarium spp.). Winter wheat of Ozon variety in pure sowing was characterized by the highest infestation by fungal diseases.

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