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CONDITION OF WINTER TRITICALE IN PURE AND MIXED SOWING

Summary

The aim of this thesis was to evaluate the impact of a sowing method (pure, 2-species and 3-species sowing) on the health condition of an ear, leaves and a stem base of winter triticale, Borowik variety. A single-factor experience was conducted in three repetitions on a very good wheat complex soil. In mixed 2-species sowing spring triticale accounted for 50% and 3-species sowing 25% and 50% of the sowing norm had a share with the participation of rye and winter wheat. The results obtained demonstrated that a sowing method differentiated significantly the intensity of leaves and ear blight septoria (Septoria nodorum) and fusarium foot rot (Fusarium spp.*) of winter triticale. As far as the compared sowing methods are concerned, winter triticale grown in a 3-species mixture with share of 25%, rye 50% and winter wheat 25% demonstrated a significantly lower index of leaves and ear blight infestation by Septoria nodorum and fusarium foot rot (Fusarium* spp.*). The highest intensity of such diseases was recorded in the winter triticale pure sowing.*
***Key words**: winter triticale, sowing method, fungal diseases*

STAN ZDROWOTNY PSZENŻYTA OZIMEGO 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 pszenżyta ozimego odmiany Borowik. Doświadczenie jednoczynnikowe prowadzono w trzech powtórzeniach na glebie kompleksu pszennego bardzo dobrego. W siewie mieszanym dwugatunkowym pszenżyto stanowiło 50%, a trójgatunkowym 25% i 50% normy wysiewu z udziałem żyta i pszenicy ozimej.Uzyskane wyniki wykazały, że sposób siewu istotnie różnicował nasilenie występowania septoriozy liści i plew (Septoria nodorum) oraz fuzaryjnej zgorzeli podstawy źdźbła (Fusarium spp.*) pszenżyta ozimego. Z porównywanych sposobów siewu, pszenżyto ozime uprawiane w mieszance trójgatunkowej, której udział stanowił 25%, żyto 50% i pszenica ozima 25% odznaczało się istotnie niższym indeksem porażenia liści i plew kłosów przez S. nodorum (septorioza) oraz podstawy źdźbła przez Fusarium* spp. *(fuzaryjna zgorzel podstawy źdźbła. Największe nasilenie tych chorób notowano w siewie czystym pszenżyta ozimego.*
***Słowa kluczowe**: pszenżyto ozime, sposób siewu, choroby grzybowe, siew czysty, siew mieszany*

1. Introduction

An increasing cereal acreage and abandonment of traditional agricultural methods, including a lack of correct rotation, results in the increased significance of mixed cereal sowing as factors limiting the negative impact of incorrect plant rotation. According to Szempliński [16] and Tratwal et al. [18] cereal mixtures increase the genetic diversity of plants in a field, contributing to better use of a productive space, raising productivity and health of plants. A main advantage of mixtures consists in their steadfast crop yield compared to pure cereal sowing. It is connected with better use of nutrients and water by respective mixture components. Inter-species mixtures and inter-variety mixtures compared to pure sowing are characterized by higher tolerance to adverse habitat and agro-technical conditions. Conditions adverse for the growth of one of mixture components may be advantageous for the development of the other that becoming dominant in a field compensates the losses of the remaining mixture components for which the conditions were disadvantageous [9, 12]. According to Michalski et al. [11] inter-species mixtures, owing to better use of a habitat, higher adaptation capabilities and use of allelopathy and synergism phenomena, yield more reliably than plants in pure sowing. According to Leszczyńska [9], cereal mixtures, by reducing plants infestation by pests, decrease outlays on plant protection chemicals and as a consequence – protect the environment against synthetic pesticides.

Within agricultural practice, cereal mixture crops apply mainly to spring cereals. Winter cereal mixtures are rare. According to Michalski et al. [11] a mixture composition may be varied. The typical ones include: cereal and legume mixtures, legume with grass and inter-species and inter-variety cereal mixtures. Tratwal et al. [18] emphasise that the application of various types of sowing is quite a simple and inexpensive method for the diversification and raising the genetic immunity of contemporary variates of plants.

An increasing interest in conducting such a type of crops is related to the increase in pesticides prices as well as tightening of the provisions of the Act on integrated plant protection which requires primarily the application of agro-technical and biological methods in pests control [18].

There are numerous studies on mixed spring cereal sowing, mainly with the share of barley and oat [7, 8, 9]. Whereas, there are only few studies on the health condition of winter triticale in mixed sowing.

The aim of this study was to evaluate the condition of leaves, ear and straw base of Borowik variety winter triticale depending on a sowing method (pure, mixed 2-species, mixed 3-species sowing).

2. Material and methods

A field research was conducted in the years 2014-2016. The experiment was performed on a very good wheat complex soil in the Experimental Agricultural Farm - Prusy near Cracow. Within this experiment, the health condition of winter triticale (Borowik variety) in pure and mixed sowing was compared. This cereal species is classified as early and fodder. It is characterized by a high yielding potential up to 118% of the standard and good frost-resistance. A great advantage of this variety consists in a relatively high resistance to fungal diseases: leaves stem rust (*Puccinia recondita)* and leaf septoriosis (*S. nodorum*) and a quite high resistance to mildew, yellow rust (*Puccinia striiformis*), fusarium of ears and straw base diseases [2].

This single-factor experiment was carried out in three repetitions. Peas were used as a pre-crop for cereals. Land cultivation and fertilization were consistent with agro-technical requirements for this species of plant. The tested plants sowing was performed in the third decade of September with the distance between rows of 14 cm.

Winter triticale (Borowik variety) in pure sowing was sown in the amount of 205 kg·ha^{-1}, 2-species mixture 102.50 kg·ha^{-1}, 3-species 51.25 kg·ha^{-1}. Winter wheat (Ozon variety) in 2-species mixture 93.90 kg·ha^{-1}, 3-species mixture 46.95 kg·ha^{-1}. Rye (Amber variety) in 2-species mixture 33.80 kg·ha^{-1}, 3-species mixture 16.90 kg·ha^{-1}. Land cultivation and fertilization were consistent with agro-technical requirements for this species of plant. In the vegetation period, cereals were not protected against pests and diseases.

The health condition of winter triticale was evaluated on 25 randomly sampled plants from each plot. In the initial milk maturity of a wheat grain (BBCH - 73), the intensity of diseases was evaluated on leaves, ears and a straw base in a four-grade scale, where: 1 means a healthy plant and 4 means infestation ≥50% of a plant [1]. The health condition of the plants tested was compared in the following combinations:

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

The results obtained are presented in the form of an infestation (disease) index (DI) according to Pierre and Regnault [15]. The calculated infestation (disease) index (DI) was subject to a variance analysis, where differences between average values were compared in Turkey's test at the level α=0.05.

3. Results and discussion

Weather conditions in the period of the tests varied (Table 1). In 2015, from April to August, only in May there was excessive humidity compared to the multiannual period. In the remaining months, from spring to harvesting, there was insufficient precipitation and increase in air temperature compared to the multiannual period. Whereas, in the same period in 2016, there was an excessive precipitation in April and July. Therefore, it may be stated that 2015 was drier and warmer than 2016.

In the vegetation period, winter triticale was attacked by wheat leaves and ear blight septoria (*Septoria nodorum*), leaves stem rust (*Puccinia recondita*), cereal and grass mildew (*Blumeria graminis*) and fusarium foot roots (*Fusarium* spp.). According to many authors [3, 5, 6, 13, 14, 18] the said diseases attack triticale with varied intensity depending on weather conditions or an agro-technique applied. According to Małecka et al. [10], Mrówczyński et al. [13], Panasiewicz et al. [14] currently, the largest damage in this cereal cultivation is done by *Blumeria graminis, Septoria nodorum* and *Puccinia triticina*.

As the authors' own research indicates, the intensity of fungal diseases of winter triticale depended on the year in which it was tested. Weather conditions in the triticale vegetation period in 2015 from April to August did not facilitate the growth of fungal diseases. In this period, there was a growing trend in the occurrence of stem rust fungus (*P. recondita*). Whereas, the hydro-technical conditions (increase in precipitation) in the same period in 2016 contributed to the growth of fungal diseases, in particular wheat leaves and ear blight septoria (*S. nodorum*) (Table 2). According to literature [3, 5, 18] the said disease is greatly dependent on precipitation occurring in a given vegetation season. Based on the authors' own research, it is observed that the highest precipitation took place in April, June and July what contributed to the development of *S. nodorum.*

Cereal mixtures, in particular the spring ones, were studied on numerous occasions. In the opinion of many authors [4-7, 9, 11, 12, 16, 17], cereal mixtures, compared to single-species sowing, demonstrate lower susceptibility to diseases and pests and make a better use of nutrients. They also protect soil against organic matter loss and limit cereal lodging. Cereal mixed sowing increases tolerance to adverse habitat conditions and reduce "soil sickness" [16].

Table 1. Weather conditions during the study (according to the Meteorological Station in Prusy)
Tab. 1. Warunki pogodowe w okresie prowadzonych badań (wg 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 triticale by fungal diseases between 2015–2016
Tab. 2. Indeks porażenia (DI) pszenżyta ozimego przez grzyby chorobotwórcze w latach 2015-20016

Years	Leaves diseases caused by			Ear blight *S. nodorum*	Fusarium foot rot *Fusarium* spp.
	S. nodorum	*P. recondita*	*B. graminis*		
2015	1.49	0.58	0.26	0.23	0.61
2016	3.15	0.32	0.48	1.64	1.14
$LSD_{0.05}$	0.20	n. s.	n. s.	1.31	n. s.

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

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

Sowing method	Leaves' diseases			Ear blight *S. nodorum*	Fusarium foot rot *Fusarium* spp.
	S. nodorum	*P. recondita*	*B. graminis*		
1.	2.97	0.20	0.68	1.17	1.18
2.	2.50	0.33	0.70	1.15	0.72
3.	2.75	0.63	0.20	0.78	0.75
4.	1.60	0.58	0.03	0.62	0.65
5.	2.32	0.48	0.43	0.88	1.05
6.	1.80	0.47	0.17	1.00	0.90
Mean	**2.32**	**0.45**	**0.37**	**0.93**	**0.87**
$LSD_{0.05}$	1.13	n. s.	n. s	0.34	0.25

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

Inter-species mixtures of winter cereals are rarely introduced to agricultural practice [4]. Our own research demonstrates that a sowing method differentiated significantly the intensity of leaves and chaff septoria (*S. nodorum*) and fusarium seedling blight of a straw base (Fusarium spp.) of winter triticale (Table 3). Borowik variety winter triticale in pure sowing was characterized by the highest infestation by pathogenic fungi. Whereas, mixed sowing decreased infestation of this cereal species by phytopathogenic fungi. A similar response was noted by Kozak et al. [6] in a cereal and legume mixture and Tratwal et al. [17] in inter-variety mixed sowing but in winter wheat. The results of the authors' own research indicate that mixed sowing significantly reduced the development of leaves and ear chaffs septoria (*S. nodorum*) and fusarium foot rot *(Fusarium* spp.). The outcomes are also consistent with the findings of Michalski et al. [12] who also observed a decrease in septoria intensity on ear leaves and chaffs of triticale in mixed sowing. Similarly, Kurowski et al. [7] confirmed the positive impact of mixed sowing on the phyto-sanitary condition of spring cereals. They observed the highest limitation of fusarium foot rot development in a cereal mixture. In the authors' own research, it was stated that among the combinations compared, 3-species mixed sowing, where winter triticale constituted only 25%, rye 50% and winter wheat 25% of the sowing standard, significantly limited the development of chaffs and leaves septoria (*S. nodorum*) and fusarium foot rot (*Fusarium* spp.). The results obtained are conform to the tests by Kurowski et al. [7] confirmed the positive impact of mixed sowing on the phyto-sanitary condition of spring cereals. They observed the highest limitation of fusarium foot rot development in a cereal mixture. In the authors' own research, it was stated that among the combinations compared, 3-species mixed sowing, where winter triticale constituted only 25%, rye 50% and winter wheat 25% of the sowing standard, significantly limited the development of chaffs and leaves septoria (*S. nodorum*) and fusarium foot rot (*Fusarium* spp.). The results obtained conform to the tests by Kurowski et al. [7] and Michalski et al. [12] who in their research demonstrated a drop in the occurrence of fusarium foot rot in cereal mixtures. Tratwal et al. [17] in an inter-variety mixture, consisting of three winter wheat varieties, observed a drop in the occurrence of *B. graminis f. sp. tritici* compared to pure sowing. As part of the authors' own research, an index of triticale leaves infestation with *B. graminis* was low and did not depend significantly on a sowing method. As far as the 3-species mixture is concerned (combination 4) a trace occurrence of cereal and grass mildew (*B. graminis*) on leaves was observed. The authors' own research demonstrates that the occurrence of stem rust fungus (*P. recondita*) on winter triticale leaves was low and did not depend significantly on a sowing method. However, it was noted that mixed sowing compared to pure sowing facilitated the development of stem rust fungus *P. recondita*. The results obtained for the observation of mildew (*B. graminis*) and stem rust fungus (*P. recondita*) did not confirm information provided in literature [7, 10, 13, 14, 17].

4. Conclusion

A sowing method differentiated significantly the intensity of leaves and ear blight septoria (*S. nodorum*) and fusarium foot rot (*Fusarium* spp.) of winter triticale. As far as the compared sowing methods are concerned, winter triticale grown in 3-species mixture with share of 25%, rye 50% and winter wheat 25% demonstrated a significantly lower index of leaves and glume blotch infestation by *S. nodorum* and fusarium foot rot by *Fusarium* spp. The highest intensity of such diseases was recorded in the winter triticale pure sowing.

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