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TECHNOLOGICAL QUALITY OF GRAIN OF SPRING WHEAT CULTIVATED AS PURE VARIETIES AND THEIR MIXTURES

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Abstract. Technological quality of grain and flour of milling mixtures 'Omega' + 'Igna' + 'Henika' and 'Omega' + 'Igna' + 'Banti', made of three varieties of grain mixed in equal proportion were compared to quality of wheat which was cultivated in mixtures of the same varieties. Before sowing those varieties were compiled in equal proportion. 'Omega' and 'Igna' are varieties susceptible to infestation by fungi unlike 'Henika' and 'Banti' varieties. Wheat was cultivated with or without fungicide protection. Hectolitre weight, content of low molecular SDS-soluble protein and number of insoluble protein in flour were more profitable for mixtures made of pure stands than variety mixtures. As far as vitreousness of grain, milling properties of grain, content of protein in grain and SDS + ME-soluble protein are concerned the quality of variety mixtures was higher for the variety mixture in comparison with mixtures made of pure stands. Fungicide protection in the cultivation of pure varieties and varieties mixtures increased value of hectolitre weight and filling and uniformity of grain.

Key words: wheat, grain, variety mixtures, milling mixtures

INTRODUCTION

Cultivation of variety mixtures is grounded on relations and their results in stand between varying varieties. Diversity of occurrences taking place in mixture is used in morphological-developing range and immunity of its components on mechanical and biological factors [Gacek et al. 1997].

In variety mixture complementation and compensation play important parts. The result of complementation consists in profitable influence of varieties on each other during the growing season. The result of compensation is connected with more profitable using of environment by one of mixture variety at the expense of others, which did not use that environment (nutrient components, water, light). In consequence the whole mixture has a high and constant yield. The decrease of infestation by diseases in variety

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mixtures is the result of decreasing amount and dispersion of susceptible varieties and also the fact of appearing of physical barrier as tissue of immune variety, which curbs spread of pathogen in stand [Lisowicz and Kaniuczak 1993].

In academic literature there are articles concerning the effect of cultivation of variety mixtures on yield and yielding features. There are only few papers concerning cultivation of varieties mixtures on the subject of grain quality. That is why it was appropriated to undertake research concerning assessment of spring wheat grain quality growing in variety mixtures and comparing it to the technological value of milling mixtures made of grain of varying varieties of wheat growing in pure stands.

MATERIALS AND METHODS

Four varieties of spring wheat: 'Omega', 'Igna', 'Henika' and 'Banti' were the research material. Those varieties were growing in pure stands and as variety mixtures. Mixtures were prepared by compiling in equal proportions the grain of 'Omega', 'Inka', 'Henika' and 'Omega', 'Igna', 'Banti' before sowing. The field experiment was conducted at Agricultural Experimental Station – Pawłowice by Department of Crop Production for two years.

The wheat was growing with or without fungicide protection. 'Omega' and 'Inka' are varieties susceptible to infestation by fungi unlike 'Henika' and 'Banti' varieties. The technological quality of grain of two milling mixtures 'Omega' + 'Igna' + 'Henika' and 'Omega' + 'Igna' + 'Banti', made of three varieties of grain mixed in equal proportions were compared to the quality of the wheat which was cultivated in varieties mixtures.

The research material was assessed on the basis of the physical properties: hectolitre weight [PN-73/R-74007], vitreousness of grain [PN-70/R-74008] and filling and uniformity of grain. Laboratory milling was made using Quadrumat Senior grinder. Content of total protein in flour was determined by Kjeldahl method (N × 5.7). Amount of low molecular SDS-soluble and SDS + ME-soluble protein were determined by Danno and Hoseney method [1982].

The results of two-year research were put through statistical calculations. One factor analysis of variance was done. Means were calculated by Duncan's test, P = 0.95.

RESULTS AND DISCUSSION

Taking into consideration the physical properties of grain it was found that varieties mixtures both with variety 'Banti' as well as 'Henika' noted for lower HL weight, but higher vitreousness than in the mixtures made of varieties growing in pure stands (Table 1). The differences of filling and uniformity of grain were not observed between varieties mixtures and mixtures made of varieties growing in pure stands for the wheat cultivated with or without fungicide protection.

According to Jankowski [1988] the higher hectolitre weight is the better grain quality is. All the milling mixtures and variety mixture O + I + H can be rated to the first quality class i.e. grain noted for HL weight over 76 $kg \cdot h^{-1}$. Mixtures made of varieties cultivating with fungicide protection noted for the highest hectolitre weight (78.45 and

Table 1. Mean values of physical properties of wheat grain

Factor		Property			
		HL weight kg·hl^{-1}	filling of grain %	uniformity of grain %	vitreousness of grain %
Without fungicide protection	O + I + H	74.80 d	78 c	78 c	77 a b
	O + I + B	75.08 d	84 b	84 b	68 c
	(O + I + H)	77.72 b	80 c	80 c	80 a
	(O + I + B)	76.30 c	84 b	84 b	61 d
With fungicide protection	O + I + H	77.82 b	86 a	86 a	82 a
	O + I + B	75.88 c d	88 a	88 a	72 b
	(O + I + H)	79.70 a	87 a	87 a	74 b
	(O + I + B)	78.45 a b	89 a	89 a	61 d

O + I + H – variety mixture: 'Omega', 'Igna' and 'Henika'.
O + I + B – variety mixture: 'Omega', 'Igna' and 'Banti'.
(O + I + H) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Henika'.
(O + I + B) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Banti'.

79.70 kg·h^{-1}). The slightly lower values of that feature were observed for mixture (O + I + H) made of varieties without protection and mixture O + I + H with protection (77.72 and 77.82 kg·h^{-1}). Varieties mixture growing without fungicide protection were characterized by the lowest hectolitre weight (75.08 and 74.80 kg·h^{-1}).

One of the most important properties showing technological value of grain is its vitreousness. It affects significantly the course of grain milling process and the final effect [Gil 1996]. The vitreousness of grain of two mixtures O + I + H and mixture made of the same varieties growing without fungicide protection was the highest (from 77 to 82%). The vitreousness of grain (O + I + B) of mixtures growing with and without fungicide protection was the lowest.

The filling of grain shows the grain size and the uniformity indicates the percentage of grain noted for similar plumpness. Those physical properties of grain are characteristic which is often used in seed production, but they are also very important as far as the technology of milling is concerned. The uniformity of grain improves its milling properties [Cacak-Pietrzak et al. 1994]. The filling and uniformity of grain were the highest for mixtures growing with fungicide protection (from 86 to 89%). Within the wheat growing without fungicide protection the differences between corresponding mixtures were not significant. In that group the material with part of 'Banti' variety noted for higher values given above (84%) than the material with the percentage of 'Henika' variety (78 and 80%).

The grain milling value is the property contributing to getting the highest amount of flour characterized by the lowest content of mineral components. The laboratory test of milling is a very useful quality test for milling industry [Sitkowski 1999].

Cultivation of variety mixtures was profitable on account of grain milling properties. It is proved by higher or equal values of variety mixtures milling properties compared to corresponding milling mixtures, without fungicide protection (Table 2).

Table 2. Mean values of milling properties of wheat grain

Factor		Property				
		yield of breaking flour %	yield of reduction flour %	yield of total flour %	yield of middlings %	middlings reduction %
Without fungicide protection	O + I + H	31.2 c	30.4 a	61.6 a	37.0 a	82.1 b
	O + I + B	32.2 b	29.0 b	61.2 a b	35.2 c	82.7 a
	(O + I + H)	30.6 d	29.8 a	60.4 b	36.2 b	82.5 a b
	(O + I + B)	31.6 c	27.1 c	58.7 c	35.2 c	76.9 d
With fungicide protection	O + I + H	32.3 b	30.2 a	62.5 a	37.4 a	80.8 c
	O + I + B	33.6 a	28.7 b	62.3 a	33.0 d	81.0 c
	(O + I + H)	31.5 c	30.4 a	61.9 a	36.5 b	83.0 a
	(O + I + B)	30.8 d	28.4 b	59.2 c	35.2 c	80.4 c

O + I + H – variety mixture: 'Omega', 'Igna' and 'Henika'.
O + I + B – variety mixture: 'Omega', 'Igna' and 'Banti'.
(O + I + H) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Henika'.
(O + I + B) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Banti'.

Yield of breaking flour O + I + H variety mixture was higher than O + I + H milling mixture for wheat growing with and without fungicide protection. The same correlation was observed for variety mixtures and mixtures made of pure stands with 'Banti' variety.

Between yield of reduction flour variety mixtures and mixtures made of pure stands with 'Henika' variety there was no significant differences. That material noted for the highest value of mentioned property (from 29.8 to 30.4%). The slightly lower amount of reduction flour was obtained from variety mixtures O + I + B (28.7 and 29.0%) and milling mixtures (O + I + B) with fungicide protection (28.4%). Milling mixture (O + I + B) without fungicide protection was characterized by the lowest yield of reduction flour (27.1%).

From among the whole variety mixtures with or without fungicide protection and from milling mixture (O + H + I) growing with the usage of fungicide protection the highest yield of total flour was observed (from 61.2 to 62.5%). The lower amount of flour was obtained from mixture (O + H + I) growing without fungicide protection (60.4%), and the lowest from two mixtures (O + I + B; 58.7 and 59.2%).

The highest yield of middlings was obtained from mixtures O + I + H (37.0 and 37.4%). The amount of middlings obtained from the separately sown mixtures with 'Henika' variety was slightly lower (36.2 and 36.5%). The material in which there was 'Banti' variety noted for low yield of middlings, and the lowest one variety mixture O + I + B with using of fungicide.

Middlings from milling mixtures O + I + H and the variety mixture O + I + B without fungicide were characterized by the best middlings reduction (from 82.5 to 83.0%). A little worse middlings reduction noted for variety mixture O + I + H without fungicide protection (82.1%). The lower amount of flour from middlings was obtained from almost all the materials with fungicide protection apart from milling mixture (O + I + H).

Milling mixture (O + I + B) without fungicide protection noted for the lowest middlings reduction (76.9%).

The research also analyses the content of protein in grain and flour and also filling composition of protein in flour, which is SDS-soluble protein, SDS + ME-soluble protein and insoluble protein. The higher amount of SDS-soluble protein badly influences on the baking quality of flour contrary to high molecular glutenin, which is SDS + ME--soluble protein [Subda 1991 a, b, Subda 1998].

By evaluating content of chemical components: total protein, low molecular SDS--soluble protein and high molecular SDS + ME-soluble protein it was found that variety mixtures contained not fewer of those components than corresponding separately sown mixtures (Table 3). Variety mixtures O + I + B contained also more protein in flour in comparison with separately sown mixtures with that variety. Variety mixture O + I + H protected with fungicide was characterized by less protein in flour than milling mixture (O + I + H) protected with fungicide. Mixtures made of varieties growing in pure stands also were characterized by higher content of insoluble protein than variety mixtures.

Table 3. Mean values of chemical properties of wheat grain and flour

Factor		Property				
		total protein in grain %	total protein in flour %	SDS-soluble protein %	SDS + ME-soluble protein %	insoluble protein %
Without fungicide protection	O + I + H	14.2 a	12.8 a	8.51 a	3.95 a	0.29 c
	O + I + B	13.2 b c	12.6 a	8.22 b c	4.07 a	0.26 c
	(O + I + H)	13.6 b	12.6 a	8.55 a	3.28 c	0.82 a
	(O + I + B)	13.2 b c	12.2 b	7.95 c	3.92 a	0.38 b
With fungicide protection	O + I + H	14.2 a	12.2 b	8.34 b	3.85 a b	0.02 d
	O + I + B	13.5 b	12.6 a	8.34 b	4.01 a	0.20 c
	(O + I + H)	13.7 b	12.9 a	8.22 b c	3.62 b	1.06 a
	(O + I + B)	12.9 c	12.1 b	8.05 c	3.52 b	0.52 b

O + I + H – variety mixture: 'Omega', 'Igna' and 'Henika'.
O + I + B – variety mixture: 'Omega', 'Igna' and 'Banti'.
(O + I + H) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Henika'.
(O + I + B) – variety mixture prepared after harvest: 'Omega', 'Igna' and 'Banti'.

Variety mixtures O + I + H noted for the highest amount of protein in grain (14.2%). The lowest content of protein in grain was characterized by milling mixture (O + I + B) with fungicide protection (12.9%). The remaining materials contained from 13.2 to 13.7% protein in grain.

Variety mixtures growing without fungicides, milling mixtures (O + I + H) and variety mixture O + I + B with fungicide contained from 12.6 to 12.9% protein in flour. The lowest amount of protein in flour (12.1, 12.2%) contained milling mixtures (O + I + B) and variety mixture O + I + H with fungicide protection.

Variety mixture and mixture made of varieties from pure stands with 'Henika' variety without fungicide protection noted for the highest amount of SDS-soluble protein (8.51, 8.55%). Almost all materials with fungicide protection apart from milling mixture (O + I + B) and variety mixture O + I + B without fungicide contained from 8.22 to 8.34% low molecular protein. Milling mixture (O + I + B) with fungicide protection characterized by the lowest amount of SDS-soluble protein (8.05%).

All the variety mixtures and milling mixture (O + I + B) without fungicide protection had the similar amount of SDS + ME-soluble protein (from 3.85 to 4.07%). The lower amount of that filling contained mixtures made of pure stands with fungicides (3.52 and 3.62%). Milling mixture (O + I + H) without fungicide protection characterized by the lowest content of SDS + ME (3.28%).

Mixtures made of pure stands (O + I + H) noted for the highest content of insoluble protein (0.82 and 1.06%). Those mixtures with 'Banti' variety contained 0.38 and 0.52% of insoluble protein. Variety mixtures contained the lowest amount of insoluble protein, especially variety mixture O + I + H with fungicide protection (0.02%).

Evaluating the effect of fungicide protection on variety mixtures and mixtures made of pure stands quality it was found that fungicide protection increased hectolitre weight and filling and uniformity, both variety mixtures and mixtures made of pure stands. Goodling et al. [2002] found that fungicides influenced the growth HL weight. According to Sułek et al. [2007] fungicide protection increased filling and uniformity of grain. Those relations are not confirmed by other research. Budzyński et al. [1995], Nowak et al. [2005] did not find correlation between using fungicides and HL weight. The same authors found that fungicides affected milling properties of grain in different ways. Cichy [1995] and Goodling et al. [2002] inform about profitable influence of fungicide on productivity of assimilation apparatus, which in consequence results in the increase of amount of protein. Nowak et al. [2005] and Sułek et al. [2007] shows the lack of connection between the content of protein and using fungicides. Furthermore in research by Zając et al. [1993] fungicides affected the decrease of protein content in grain of examined varieties by 2.5%. According to Narkiewicz-Jodko et al. [2008] fungicide protection did not influence the physical properties and protein content of barley grain. In the research done by the writer fungicides increased yield of breaking flour and decreased middlings reduction, content of total protein in flour, SDS-soluble protein and insoluble protein in relation to variety mixture O + I + H. Fungicide protection used in variety mixture O + I + B increased vitreousness and yield of breaking flour. Using fungicides also decreased the yield of middlings and middlings reduction. Milling mixture (O + I + H) with fungicide protection in comparison with the same mixture without fungicide protection are characterized by higher values of yield of total and breaking flour, content of SDS + ME-soluble protein. Using fungicide protection also affected amount of low molecular SDS-soluble. However that practice decreased vitreousness of grain. By comparing milling mixture (O + I + B) with fungicide protection with milling mixture (O + I + B) without using fungicides the profitable effect of fungicides on yield of reduction flour and middlings reduction was observed. The protection of varieties of that mixture decreased the yield of breaking flour as well as the amount of protein in grain and high molecular protein.

CONCLUSIONS

1. Technological quality of variety mixtures was more profitable than the values of mixtures made of pure stands as far as vitreousness and milling properties of grain, content of total protein in grain, content of high molecular SDS + ME-soluble protein.

2. Mixtures made of pure stands in comparison with variety mixtures were characterized by higher hectoliter weight, lower content low molecular SDS-soluble protein and higher amount of insoluble protein.

3. Variety mixtures and mixtures made of pure stands with 'Henika' variety noted for profitable quality characteristics in comparison with variety mixtures and mixtures made of pure stands with 'Banti' variety.

4. Fungicides used in cultivation of pure varieties as well as variety mixtures increased the value of hectolitre weight and filling and uniformity of grain.

REFERENCES

Budzyński W., Fedejko B., Szempliński W., Majewska K., 1995. Energetyczna, produkcyjna oraz jakościowa ocena różnych technologii uprawy ozimej pszenicy chlebowej [Energy, production and quality assessment of different crops cultivation of winter wheat]. Fragm. Agron. 47, 35-51 [in Polish].

Cacak-Pietrzak G., Haber T., Łagowska G., Sitkowski T., 1994. Wybrane cechy fizyczne i skład chemiczny ziarna niektórych pszenic krajowych [Chosen physical qualities and chemical analysis of some domestic wheat varieties]. Prz. Zboż. Młyn. 8, 18-20 [in Polish].

Cichy H., 1995. Reakcja pszenżyta jarego i pszenicy na fungicydy i antywylegacz. Cz. 2. Wpływ na wybrane cechy rolnicze [Reaction of spring triticale and wheat on the fungicide protection and retardant. Vol. 2. Influence on the chose agricultural properties]. Biul. IHAR 195/196, 167-172 [in Polish].

Danno G., Hoseney R.C., 1982. Changes in flour proteins during dough mixing. Cereal Chem. 59, 249-253.

Gacek E., Czembor H., Nadziak J., 1997. Zastosowanie mieszanin odmian do poprawy zdrowotności oraz wysokości plonowania pszenicy ozimej [Application of mixtures varieties for improvement of health and yielding of winter wheat]. Biul. IHAR 201, 81-95 [in Polish].

Gooding M.J., Dimmock J.P.R.E., Ruske R., Peples S., Ford K.E., Gregory P.J., 2002. The effect of fungicides on the yield and quality of wheat grain. VII Congress ESA Book of Proceedings. Cordoba, 15-16.07.2002, 441-443.

Gil Z., 1996. Wartość technologiczna odmian pszenżyta jarego i ozimego w zależności od warunków środowiska [Technological value of spring and winter triticale cultivars in depending on environmental conditions]. Zesz. Nauk. AR Wroc. 298, Tech. Żywn. 147 [in Polish].

Jankowski S., 1988. Surowce mączne i kaszowe, ziarno zbóż, gryki i grochu [Flour and groats materials, grain of cereal, buckwheat and pea]. WNT Warszawa [in Polish].

Lisowicz F., Kaniuczak Z., 1993. Wpływ upraw mieszanin odmian na zdrowotność i plon pszenicy [Influence of variety mixtures cultivation on health and yield of wheat]. Pr. Nauk. Inst. Ochr. Rośl. 33, 126-132 [in Polish].

Narkiewicz-Jodko M., Mularczyk A., Urban M., 2008. The influence of fungicides on quality and health of spring barley grain. Prog. Plant/Post. Ochr. Roślin (in press).

Nowak W., Sowiński J., Pietr S.J., Kita W., 2005. The effect of plant protection treatments on the quality of winter wheat grain. Pam. Puł. 139, 117-127.

PN-70/R-74008. Ziarno zbóż. Oznaczanie ziaren szklistych [Cereals – Determination of virtuousness; in Polish].

PN-73/R-74007. Ziarno zbóż. Oznaczanie gęstości [Cereals – Determination of bulk density, called "mass per hectolitre"; in Polish].
Sitkowski T., 1999. Ocena wartości przemiałowej i wypiekowej ziarna pszenicy ze zbiorów 1998 roku [Assesment of the milling and baking quality of wheat grain from the 1998]. Prz. Zboż. Młyn. 12, 33-34.
Subda H., 1998. Określenie różnych form białka oraz ocena ich wpływu na wartość wypiekową pszenicy [The determination of different form of protein and estimation of their effect on the baking value of wheat flour]. Zesz. Nauk. AR Wroc. Tech. Żywn. 10, 1-5.
Sułek A., Podolska G., Cacak-Pietrzak G., Ceglińska A., 2007. Influence of application time of fungicide Amistar 250 SC on grain yield and quality of spring wheat cv. Nawra. Prog. Plant/Post. Ochr. Roślin 47 (2), 352-355.
Zając T., Borczyk J., Ciepla C., Pryga M., 1993. Wpływ technologii stosowania nawozów azotowych oraz retardanta wzrostu i fungicydu na wysokość i strukturę plonu pszenicy jarej [Effect of nitrogen fertilization, retardant and fungicides on yield of spring wheat]. Zesz. Nauk. AR Krak. Roln. 31, 141-152.

WARTOŚĆ TECHNOLOGICZNA ZIARNA ODMIAN PSZENICY JAREJ W MIESZANINACH UPRAWOWYCH I MIESZANKACH PRZEMIAŁOWYCH

Streszczenie. Porównywano jakość technologiczną ziarna i mąki mieszanek przemiałowych 'Omega' + 'Igna' + 'Henika' i 'Omega' + 'Igna' + 'Banti' – sporządzonych z ziarna trzech odmian, zmieszanych w równych ilościach, z jakością pszenicy uzyskanej z uprawy mieszanin tych samych odmian, zestawionych przed siewem w równych proporcjach. 'Omega' i 'Igna' należą do odmian wrażliwych na porażenie przez grzyby w przeciwieństwie do odmian 'Henika' i 'Banti'. Pszenicę uprawiano z zastosowaniem i bez zastosowania ochrony fungicydowej. Gęstość ziarna w stanie zsypnym, zawartość białka niskocząsteczkowego, rozpuszczalnego w SDS i ilość białek nierozpuszczalnych w mące były bardziej korzystne w mieszankach sporządzonych z odmian z siewu czystego, niż w mieszaninach uprawowych. Natomiast jakość mieszanin uprawowych okazała się lepsza, w porównaniu z mieszankami sporządzonymi z odmian z siewu czystego, pod względem szklistości i cech przemiałowych ziarna, zawartości białka w ziarnie i zawartości białka wysokocząsteczkowego – rozpuszczalnego w SDS + ME. Ochrona fungicydowa w uprawie odmian czystych i mieszanin odmianowych wpłynęła na wzrost wartości masy hektolitrowej oraz celności i wyrównania ziarna.

Słowa kluczowe: pszenica, ziarno, mieszaniny odmianowe, mieszanki przemiałowe

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