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YIELDING OF TWO SPRING WHEAT VARIETIES, GROWN IN PURE SOWING AND MIXTURES WITH SPRING TRITICALE ON LIGHT SOIL

Summary

The aim of this study was to compare the efficiency of sowing clean and mixtures of spring wheat and triticale, on light soil without the use of chemical production means. The field experiment was conducted in 2009-2011, in a randomized block system with four replications. Varieties of wheat: Bombona and Zadra and Dublet triticale grown in pure sowing and in their mutual mixtures: Bombona+Zadra, Bombona+Dublet and Zadra+Dublet. Mixtures were seeded in a proportion of 50/50% relative to pure seed. Grain crops and the number of stems and crop components were determined. The studies have shown that the spring triticale in pure sowing was the most efficient in yielding - significantly higher than spring wheat varieties and mixtures of: Bombona+Zadra and Bombona+Dublet. It was the result of higher values for all components in triticale crops. Mixtures of crops on average, were similar to the median of their constituent components, however, they showed a large variation over the years. In a favorable year 2010 for cereals, they yielded below expectations, but they yielded the best in the low yielding year (2011). The cultivar mixture of wheat did not differ from the wheat and triticale - wheat mixtures. Among the interspeces mixtures, a combination Zadra+Doublet showed the trend towards higher yielding.
***Key words**: cereal, mixtures, crop structure, the reaction of varieties*

PLONOWANIE DWÓCH ODMIAN PSZENICY JAREJ, UPRAWIANEJ W SIEWIE CZYSTYM I MIESZANKACH Z PSZENŻYTEM JARYM NA GLEBIE LEKKIEJ

Streszczenie

*Celem podjętych badań było porównanie wydajności siewów czystych i mieszanek pszenicy jarej i pszenżyta, na glebie lekkiej, bez stosowania nawozów i chemicznych środków ochrony roślin. Doświadczenie polowe przeprowadzono w latach 2009-2011, w układzie losowanych bloków, w czterech powtórzeniach. Odmiany pszenicy: Bombona i Zadra oraz pszenżyto Dublet uprawiano w siewie czystym oraz we wzajemnych mieszankach: Bombona+Zadra, Bombona+Dublet oraz Zadra+Dublet. Mieszanki wysiewano w proporcji 50/50% w relacji do siewu czystego. Określano plony ziarna oraz liczbę źdźbeł i komponenty plonowania. W badaniach wykazano, że najwyżej plonowało p*szenżyto jare w siewie czystym - istotnie wyżej od odmian *pszenicy jarej i mieszanek Bombona+Zadra oraz Bombona+Dublet. Było to wynikiem wyższych wartości w pszenżycie dla wszystkich komponentów plonowania. Plony mieszanek w ujęciu średnim były zbliżone do mediany z tworzących je komponentów, wykazywały jednakże dużą zmienność w latach. W korzystnym dla zbóż roku 2010 plonowały poniżej oczekiwań, natomiast najlepiej wypadły w roku słabego plonowania (2011).*
Mieszanka odmianowa pszenicy nie różniła się wydajnością od pszenicy oraz mieszanek pszenicy z pszenżytem. Spośród mieszanek międzygatunkowych, tendencję do wyższego plonowania wykazywała kombinacja Zadra+Dublet.
***Słowa kluczowe**: zboża, mieszanki, struktura plonu, reakcja odmian*

1. Introduction

With such advantages as: a lower response to changing environmental conditions, a higher level of health and higher fodder value [4, 5, 6, 9, 16], cereals mixtures became a characteristic feature of Polish agriculture of the second half of the twentieth century, with acreage of 1,5 million hectares. In recent years, sown cereal mixtures decreased to approx. 900 thousand ha, including spring mixtures to 757 thousand ha [2]. It is connected with the intensification of agriculture. Today, interest in the mixtures crop is due to the new trends in agricultural production, aimed in the direction of integrated and organic agriculture.

Growing of cereals in the form of mixtures increases the diversity of crop, which promotes health and allows obtaining better performance plants. Growing in the compound is particularly suitable for organic farming, where the use of agrochemicals is excluded and the whole agrotechnology should limit the occurrence of diseases and pests [3, 9].

The appropriate choice of species (cultivars) with high fertility and adaptation to habitat conditions is an important factor in determining the level and quality of the crop mixtures. Between species and cultivars there are clear morphological, developmental, climate, soil and agronomic differences [13]. Spring wheat is characterized by a high utility value, so it is willingly cultivated by farmers. However, it is sensitive to a lower pH and worse soil conditions; it also requires a better supply of nutrients and water [11]. A triticale is a species more tolerant to weak soil conditions, less sick, reacts by less crop reduction to a worse agrotechnology or deficiencies of nutrients [7, 11, 16]. Such differences can be used in a well-structured mixtures [15].

The aim of the tests was to compare the crop of mixtures of two spring wheat varieties: boneless and bony and spring triticale comparing with their clean sowing. The research was conducted on light soil in the conditions corre-

sponding to the first year of conversion to organic farming. Efficiency, crop components and the response of individual varieties on the crop in mixtures were evaluated.

2. Material and methods

The field experiment was carried out in 2009-2011 in Swadzim near Poznań [52°45'N 16°75'E] in the Department of Experimental and Didactic Gorzyń of Poznań University of Life Sciences, in randomized block design with four replications. The crop and crop components of spring wheat (Triticum aestivum ssp. vulgare L.) and spring triticale (Triticale), sown clean and as mixtures were analyzed. The tests included two varieties of wheat: 'Bombona' and 'Zadra' and one variety of spring triticale 'Doublet'. In three of mutual mixtures (Bombona+Zadra, Bombona+Doublet, Zadra+Doublet), they were sown in a 50/50% proportion to the density used in clean sowing (550 seeds/m^2).

The experiment was conducted on a sandy-loam soil, good rye complex of 4.b class. The size of the plots was 14,0 m^2. Cereal sowings were made at the optimum time of: 01.04 (2009), 26.03 (2010) and 25.03 (2011), in well-prepared soil. Grain was harvested at full maturity stage, in the first half of August. Neither mineral fertilizers nor chemical pesticides were used. In order to weed control of crops, the harrowing was used twice.

At the turn of June and July samples of plant were taken to assess the number of stalks, ears and fusels - from six points of each plot, with a total area of 0,235 m^2. After full maturity, before harvesting 50 ears from each plot were taken to determine the number of grains per ear and weight of thousand grains. In case of the mixtures, the samples of ears were collected separately for each component. After a plot combine threshing grain moisture was rated and grain yield was determined at 15% of humidity. The significance of the effects of experimental factors on the observed characteristics were assessed using analysis of variance, setting the half-intervals of confidence using Tukey's test at a significance level $\alpha = 0,05$.

Weather conditions were determined using a ten-day and monthly rainfall and average temperatures referred to weather station in Swadzim. The level of humidity was determined by means of Selianinov hydrothermal coefficient, calculated according to the formula:

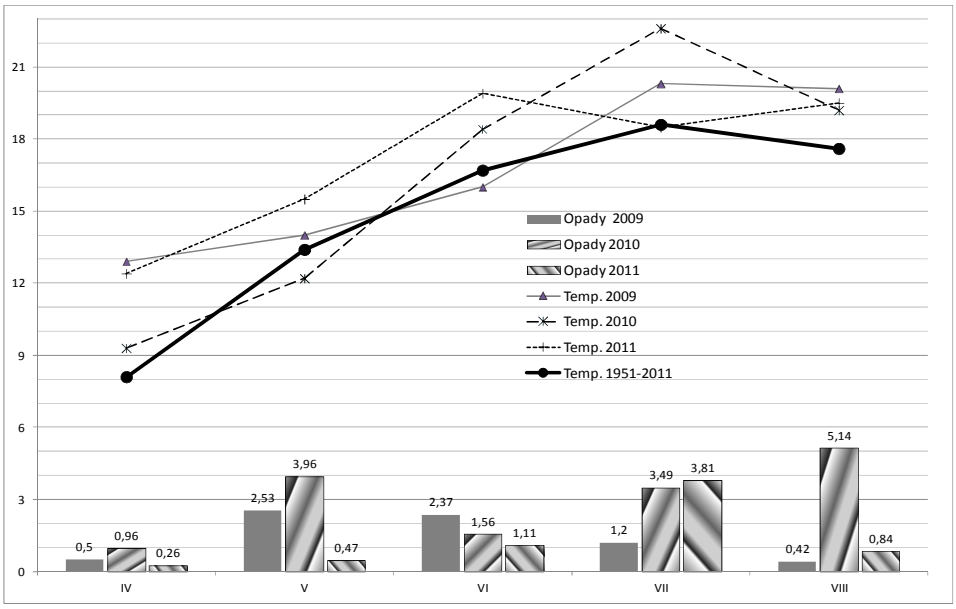
$$K = P \bullet 10/T \bullet l,$$

where P - total rainfall for the month, T - the average temperature of the month, l - the number of days in a month [12]. It is assumed that the K value amounting to 1-1,5 means that the humidity is sufficient; 0,5-1,0 of inadequate humidity (half-drought) and K<0,5 means drought.

3. Results and Discussion

Weather conditions at the time of the experiment were variable. In all the years the average temperature of the period April-July exceeded by 1,5-2 ° the long-term average temperature (14,2 ° C) and rainfall amounted to 318, 278 and 318 mm, which significantly exceeded the long-term average rainfall (215 mm). The most beneficial for spring cereals was 2010 season, with an optimal total rainfall and its good distribution during the growing season (Fig. 1). During tillering, stem elongation and heading, average temperatures prevailed, which at the abundance of water well affected the various components of crop.

Quite good conditions also prevailed in 2009, but due to the drought in April and high rainfall in May and June, production results were worse than in 2010. Conditions of 2011 proved to be the least favorable for crops. In that year, rainfalls from April until mid-June were very low, which, combined with high temperatures in excess of 2-4° long-term average temperatures resulted in the rapid evaporation of winter water and soil drought. It is well illustrated by the hydrothermal coefficient whose value for the April and May amounted to 0,25 and 0,47, which amounts much below the value „1", adopted as the lower limit of sufficient humidity (Fig. 1). Improving humidity conditions occurred only in the third decade of June and July, but heavy rains caused further losses in crops.



Source: own work / Źródło: opracowanie własne

Fig. 1. Average temperature and hydrothermal Selianinov coefficient for each month during the growing season in 2009-2011
Rys. 1. Średnie temperatury i wartość współczynnika hydrotermicznego Selianinowa dla poszczególnych miesięcy w okresie wegetacyjnym w latach 2009-2011

Among the studied cultivars of cereals, the highest grain crops were obtained with Dublet triticale, but they were characterized by the largest coefficient of variation (Table 1). Indeed, both varieties of wheat yielded less: Bombona and Zadra. The higher level of yielding of triticale in pure sowing was due to better tillering and producing a greater number of spikes compared to other combination test. This result is also consistent with previous research carried out under similar conditions [5, 7, 23]. Literature reports that the prevalence of triticale above wheat occurs also at excellent soil [13] as well as in the case of winter-growing forms of these species [1].

The working hypothesis assumes that under conditions of weaker soils triticale would be better to grow and crop than wheat, so it would therefore be a good component for mixtures. The results do not fully confirm the hypothesis. The average for the mix crop was 31,1 dt·ha^{-1}, ie. by 0,5 dt lower than the crop of pure seed. However, deviations of crop of individual mixtures from the expected values were insignificant: from +0,3 to -1,7 dt·ha^{-1}, which is no more than 6%. Crops of individual mixtures were not significantly different.

Relatively the best crop was obtained with the mixture of Zadra+Dublet at a relatively low coefficient of variation, but also showed the greatest deviation from the expected value. Yields of intervarietal mixture of Bombona+Zadra were close to the expected values, but they were also about 6% lower than the best mixtures. The results are therefore consistent with the assumption that the cultivation of mixtures should give yields at least at the average level of the yield components in pure [3, 5, 8, 14, 15, 19]. However, cropping of well balanced mixtures may be higher, closer to the level of better component and occasionally even higher - what largely depends on the selection of varieties [5, 8, 12]. The number of ears effects on a level of crops for mixtures. It was also a little lower than expected but the differences were not significant and relatively deviations did not exceed 7% (Table 1).

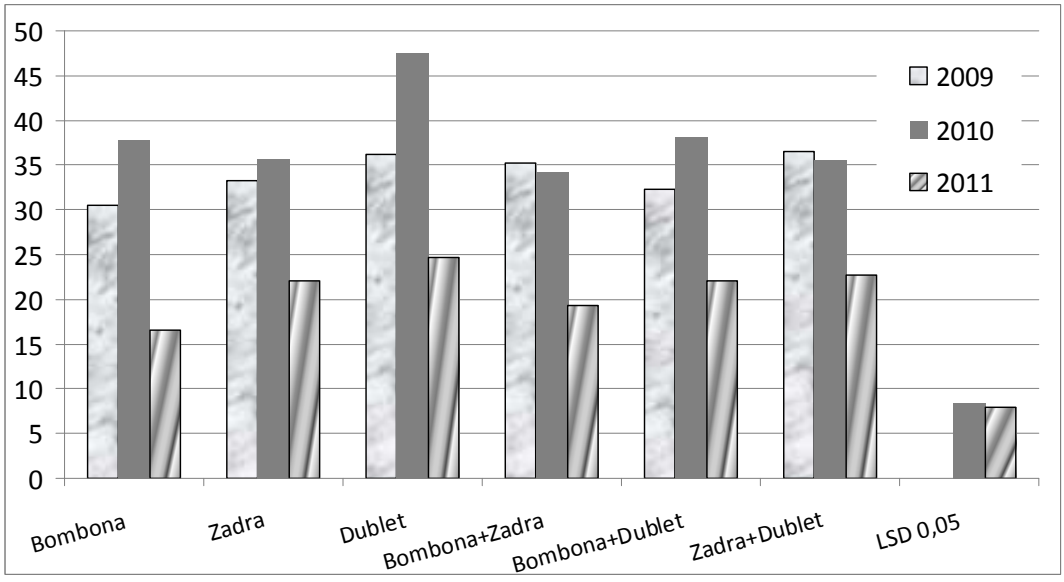
For farmers, the most important prerequisite for growing crops in mixtures is to strive to reduce differences in yield resulting from the course of various weather conditions of the years and the soil variability of fields [6, 15]. Own results partially confirm the thesis of greater fidelity to yield mixtures than cereals in pure. The coefficient of variation calculated for crops in years and replicates (n = 12) was at the level of 23-35%, which is within the limits of variation on average (Table 1). However, while the average volatility for pure sowing was 30,6%, whereas for the mixtures was lower and amounted to 26%.

Analyzing crops in subsequent years, big differences could be noticed (Fig. 2), which was connected with the course of the weather conditions.

Table 1. The number of ears and grain yields of tested cultivars and their mixtures relative to the expected values
Tab. 1. Liczba kłosów i plony ziarna badanych odmian i oraz ich mieszanek na tle wartości oczekiwanych

Cultivars	Number of ears [piece·m^{-2}]				Grain yields [dt·ha^{-1}]			
	2009-2011	expected values	deviation of expected values	variation coefficient (CV) %	2009-2011	expected values	deviation of expected values	variation coefficient (CV) %
Bombona	417,8	-	-	15,5	28,31	-	-	34,9
Zadra	384,1	-	-	8,6	30,33	-	-	27,7
Dublet	463,9	-	-	24,4	36,14	-	-	29,3
Bombona+Zadra	394,6	400,95	-6,35	15,4	29,65	29,32	0,33	29,10
Bombona+Dublet	415,1	440,85	-25,75	11,0	30,84	32,23	-1,39	28,70
Zadra+Dublet	392,7	424,00	-31,30	20,5	31,58	33,24	-1,66	23,10
LSD 0,05	*66,36*	-	-	-	*5,00*	-	-	-

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 2. Grain yields of the tested cultivars and their mixtures in years of research [dt·ha^{-1}]
Rys. 2. Plony ziarna badanych odmian i ich mieszanek w latach badań [dt·ha^{-1}]

It is characteristic that the mixtures came out the worst in good 2010 to yielding, cropping lower by about 11% than the expected values, whereas in 2009, and a very dry spring of 2011 crops of mixtures were higher than expected at average by 6%. In 2009 and 2011 the best crop were from mixture Zadra+Dublet (+10%). It should also be noted that the bone Zadra variety of wheat was better cropped in the years yielded less favorable, while in 2010 the high yielding - persisted Bombona variety. However, one must be emphasized that in any of the years or the synthesis of the results, the differences between the two varieties were not significant.

In the group of organisms creating the mixture there occur various relations, including due to competition for natural resources. The competition starts already in early stages and can continue until the end of vegetation. Its effect can be a change in population, ears fertility and crop mass. Mostly, competitive assessment is based on a comparison of the final result – crop [19, 21, 22]. Own results suggest that competition among the components of the mixtures was similar to, or even slightly higher than in the context of their own species, as evidenced by slightly lower crop mixtures compared to the expected values (Table 1). Plant growth and size of yield structure indicate development conditions prevailing in the field of corn. In the case of cereal crops in mixtures number of ears and stalks and ear size depend not only on the site conditions, but also on the effect of associated plant varieties/species [10, 14, 20, 21]. Tables 2-4 show the evolution of the parameters in the mixtures compared to pure seed for the different tested varieties.

Spring wheat represented in the tests by Bombona and Zadra cultivars, in mixtures of Dublet triticale was characterized by fewer stalks and ears in the corn, which were lower by about 3-4% than the expected values. It was also significantly lower number of grains per spike in comparison to plants of the species growing in pure, with differences of 10-14%. Weight of 1000 grains of Bombona variety in mixture with triticale was similar to the value in pure, and the Zadra variety reacted negatively (Tables 2-3).

Table 2. Bombona cultivar reaction on sowing in mixtures
Tab. 2. Reakcja odmiany Bombona na zasiew w mieszankach

Data	Cultivars	Number of stalks [pieces□m^{-2}]	Number of ears [pieces□m^{-2}]	Ears share* [%]	Number of fusels [pieces·m^{-2}]	Number of grains per ear [pieces·m^{-2}]	Mass of 1000 grains [g]
Real values	Bombona	464,6	417,8	-	38,6	34,0	35,4
	Bombona+Zadra	249,6	221,3	56,2	30,3	32,7	35,9
	Bombona+Dublet	217,1	191,7	46,9	24,4	29,3	36,1
	LSD 0,05	39,73	44,58	-	r.n.	1,98	r.n.
Relative value	Bombona	*100*	*100*		*100*	*100*	*100*
	Bombona+Zadra	*53,7*	*53,0*		*78,5*	*96,2*	*101,4*
	Bombona+Dublet	*46,7*	*45,9*		*63,2*	*86,2*	*102,0*

*- calculated to the total number of ears in the mixture (Tab. 1)

Source: own work / Źródło: opracowanie własne

Table 3. Zadra cultivar reaction on sowing in mixtures
Tab. 3. Reakcja odmiany Zadra na zasiew w mieszankach

Data	Cultivars	Number of stalks [pieces□m^{-2}]	Number of ears [pieces□m^{-2}]	Ears share* [%]	Number of fusels [pieces·m^{-2}]	Number of grains per ear [pieces·m^{-2}]	Mass of 1000 grains [g]
Real values	Zadra	403,5	384,1	-	11,7	37,1	37
	Zadra+Bombona	182,6	173,3	43,92	15,6	32,2	34,6
	Zadra+Dublet	196,4	183,8	46,66	22,3	33,6	35,3
	LSD 0,05	21,34	20,4	-	8,16	2,51	r.n.
Relative value	Zadra	*100*	*100*		*100*	*100*	*100*
	Zadra+Bombona	*45,3*	*44,8*		*47,6*	*86,8*	*93,5*
	Zadra+Dublet	*48,7*	*47,5*		*68,6*	*90,6*	*95,4*

*- look Tab. 2

Source: own work / Źródło: opracowanie własne

Table 4 Doublet cultivar reaction on sowing in mixtures
Tab. 4. Reakcja odmiany Dublet na zasiew w mieszankach

Data	Cultivars	Number of stalks [pieces□m^{-2}]	Number of ears [pieces□m^{-2}]	Ears share* [%]	Number of fusels [pieces·m^{-2}]	Number of grains per ear [pieces·m^{-2}]	Mass of 1000 grains [g]
Real values	Dublet	496	463,9	-	35,8	38,2	39,3
	Dublet+Bombona	235,2	216,7	*53,06*	18,40	36,2	38,3
	Dublet+Zadra	225,3	210,1	*53,34*	15,20	36,5	37,6
	LSD 0,05	33,89	40,70	-	r.n.	r.n.	r.n.
Relative value	Dublet	*100*	*100*		*100*	*100*	*100*
	Dublet+Bombona	*47,4*	*46,7*		*51,4*	*94,8*	*97,5*
	Dublet+Zadra	*45,4*	*45,3*		*42,5*	*95,5*	*95,7*

*- look Tab. 2

Source: own work / Źródło: opracowanie własne

A cultivar Bombona showed improved competitiveness in the mixture of wheat varieties: in the mixture there was about 12% of ears more than of a Zadra cultivar and did not reduce the mass of 1000 grains. Zadra cultivar in that varietal mix was characterized by a smaller amount of ears and significantly lower (13,2%) number of grains per spike, and the low weight of 1000 grains. It resolved Bombona, although in pure sowing it showed a tendency for higher crops, as in the tests performed by COBORU and IUNG [3].

The assessment of triticale Dublet reaction for sowing in mixtures yielded inconclusive results. Grown in the mixtures had a larger number of grains per spike and weight of 1000 grains like wheat; more frequently it was also a number of spike. At the same time yielding components of triticale growing in mixtures shaped lower than in pure stand of this species, as in previous tests [8]. As a result of the addition of triticale as a component of the mixture did not cause significant yield-forming effect.

4. Conclusions

1. The yields spring triticale was significantly higher than Bombona and Zadra spring wheat cultivars. It was due to its higher value of all components of yield.
2. Yields of mixtures were on average similar to the median of their constituent components, however, they showed a large variation in the period. In a preferred 2010 year for cereals, they yielded below expectations, but they came out the best in the low yielding year (2011).
3. Varietal mixture of wheat did not differ at the efficiency from the average for both varieties of wheat and wheat mixtures of triticale. Among the interspecific mixtures, the trend towards higher yield showed a combination of Zadra+Dublet.

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