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The impact of plant row spacing on border effect in the case of spring wheat

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Abstract: *The impact of plant row spacing on border effect in the case of spring wheat.* The field research study was conducted to examine the impact of row spacing on border effect in spring wheat. Plants growing in a dense canopy and rows separated by tramlines were compared. Tramlines applied in field research varied in width – they were either 32.4 or 43.2 cm wide. It was found that increasing of tramline width from 32.4 to 43.2 cm did not lead to substantial changes in the border effect, which amounted to 65 and 66%, respectively. Vertical range of the border effect encompassed the two subsequent rows of plants, growing on both sides of the tramline.

Key words: border effect, tramline width, spring wheat

INTRODUCTION

Border effect, that is, greater size of vegetative and generative organs of plants, has been observed along the edges of production fields, experimental land plots and in rows adjacent to unsown tramlines. Plants occupying outer rows have more space for growth and better access to nutrients, water and sunlight in comparison with plants growing inside a canopy. This phenomenon is of no significance in productive fields, as the share of perimeter of the field to the area is small. However, in tramline farming, it plays a significant role in compensation of yield losses due to reduction of area occupied by the plants. In agricultural experiments, when research is conducted in fields of small area, it is a source of variability, which may influence the experimental error and reliability of assessment of site effects, it may distort the individual plant yielding results, as well as the yield structure [Braun 1980, Stawiana-Kosiorek et al. 2003, Rudnicki and Gałęzewski 2008].

The scope of border effect depends on the plant species [Braun 1980, Brunotte and Sommer 1993, Hadjichristodoulou 1993, Niemczyk 1997, Buliński and Niemczyk 2010, 2015, Buliński et al. 2011, Niemczyk and Buliński 2012, Stawiana-Kosiorek et al. 2003, Gałęzewski et al. 2013], tramline width and sowing rate [Rudnicki and Gałęzewski 2006, 2008]. Tramline width in experimental fields may vary. In the case of productive fields, tramline width may depend on the width of tires of the plant care machines used. The existing tramline technologies allow for use of wide tires in agricultural machines, which leads to reduction of pressure on the soil, thus mitigating the extent and depth of soil consolidation after the passing of machines [Brunotte and Sommer 1993, Powałka and Buliński 2005, Buliński and Sergiel 2012, Waszkiewicz et al. 2012].

In literature, little has been written on the impact of tramline width on border effect. The available data seems to indicate that border effect increases along with tramline width to a certain limit; after this limit is exceeded, further increasing of the tramline width no longer leads to increasing of the plant yield in the outer rows [Widdowson 1973, Rudnicki and Gałęzewski 2008].

The objective of this study was to determine the correlation between tramline width and border effect, occurring in plant rows adjacent to unsown area. The research results obtained may provide an answer to the question of whether excessive widening of tramlines results in deepening of yield losses due to unsown area.

MATERIAL AND METHODS

Tests were conducted on a productive field belonging to an individual farm, falling into the very good rye soil class. Spring wheat was sown, and the row spacing value was 10.8 cm. In the phase of emergence, three sites were designated in random locations:

- L – a dense canopy with rows spaced as during sowing, that is, every 10.8 cm (as the reference site);
- S1 – with a tramline in the middle of the field of the width of 32.4 cm;
- S2 – with a tramline in the middle of the field of the width of 43.2 cm.

Tramlines were obtained by removing 2 or 3 rows of plants. In each site, 5 plots were designated of length of 1 m and width of 6 plant rows; in sites S1 and S2, the plots encompassed three plant rows on both sides of the tramline (Fig. 1).

Each plant row within the plots was subjected to detailed examination. In the vegetation period, the number of plants was recorded after emergence and after

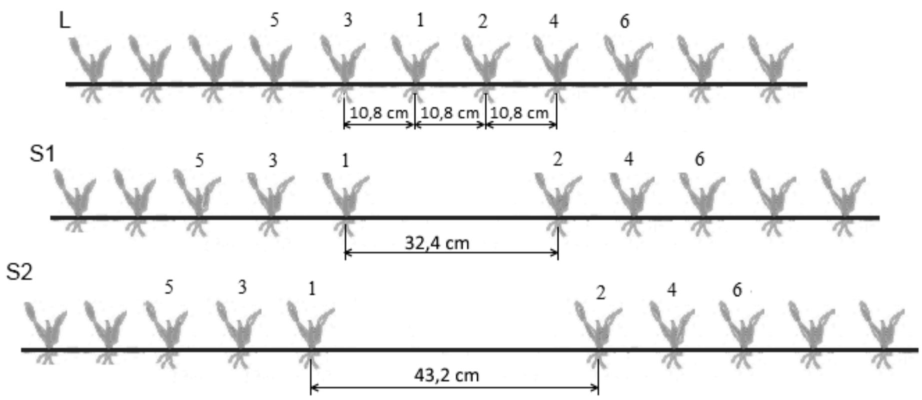

FIGURE 1. The measurement system diagram for individual sites

tillering; plants were harvested manually from each row. The parameters obtained served as a basis for assessment of the following characteristics: number of spikes, grain and straw yield, number of grains per spike and thousand-seed weight.

The results obtained were processed statistically using the STATGRAPHIC Plus software.

RESULTS

The growth space of plants on the plots varied; as a result, the plants had access to different amounts of water, nutrients and sun rays. The area per plant in a dense canopy (L) and in internal rows (3, 4, 5, 6) of sites S1 and S2 (Fig. 1) amounted to 23.7 cm^2, and in the outer rows (1, 2) in site S1 – (tramline width of 32.4 cm), it was 47.1 cm^2, and in site S2, (tramline width 43.2 cm) – almost 59 cm^2.

Such diversified living conditions may influence the growth, development and yield of the plants.

Average values, specified for the examined features in the three sites, have been presented in Figures 2, 3 and 4. Examination of average values of features examined in individual sites indicates that the number of plants (Lr) after emergence within 1 m in the examined sites, depending on row, ranged between 40 and 49 plants, and no correlation was found between the value and location of the row within the site. Variability indexes for this feature, which, for individual sites, are as follows: L – 16%, S1–15.4%, S2 – 10.4%, can be considered to be low. A comparison of average site values for this feature indicated no significance of diversification (Table 1), which serves as a basis for hypothesizing that the mode

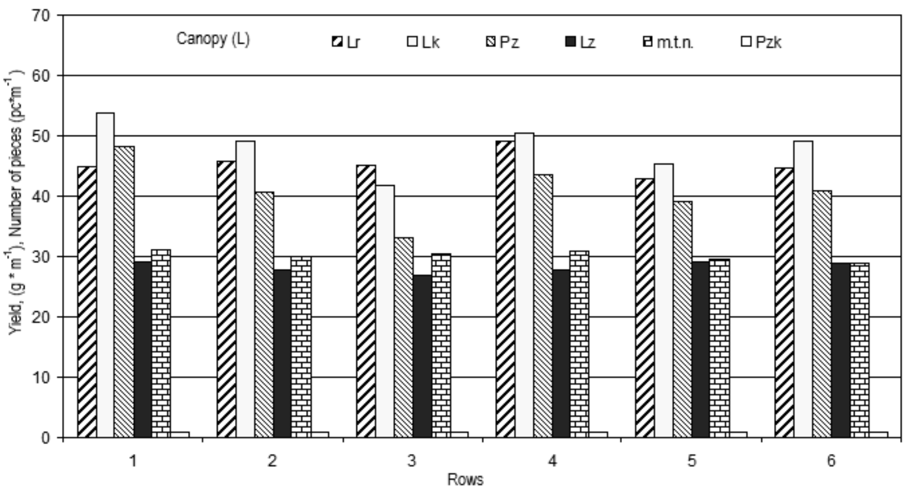

FIGURE 2. Values of individual features in the canopy (L) where: Lr = number of plants in 1 m of the row, Lk – number of spikes in 1 m of the row, Pz – grain yield in 1 m of the row, Lz – number of grains per spike, m.t.n. – thousand seed weight, Pzk – grain mass per spike

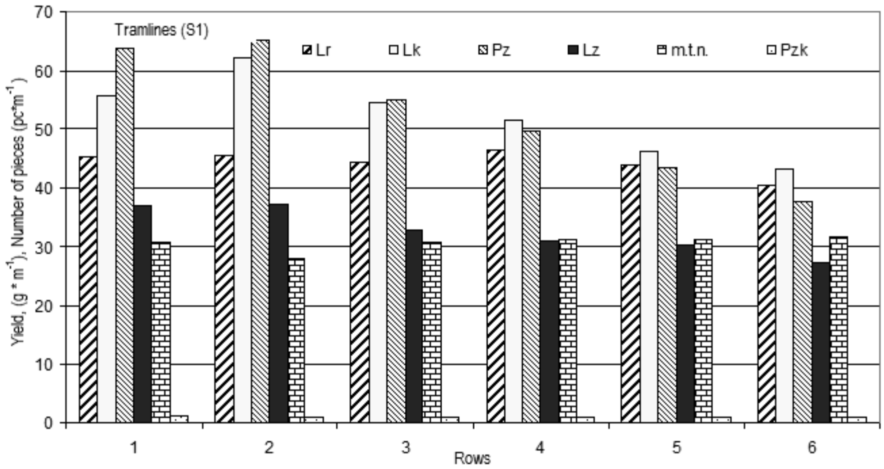

FIGURE 3. Values of individual features in the site with tramline width of 32.4 cm (S1) – marked as in Figure 2

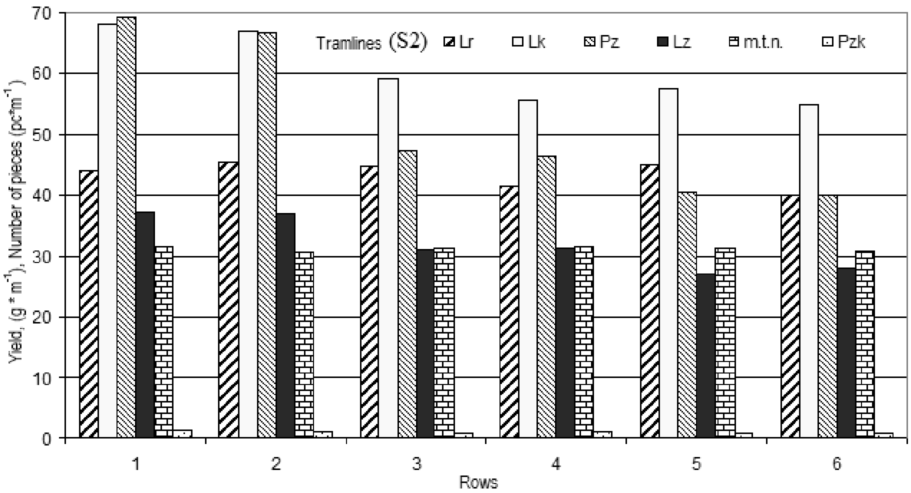

FIGURE 4. Values of individual features in the site with tramline width of 43.2 cm (S2) – marked as in Figure 2

of selection of research sites on the productive field was appropriate.

The average number of spikes (Lk) per 1 m of the row in the canopy amounted to 48.2, and it was not significantly diversified in individual plot rows. In both sites with tramlines (S1 and S2), a significant increase in the number of spikes was recorded in rows adjacent to the tramline. These values, for individual rows in the sites, ranged from 55 to 69, and the average for both sites was 59, that is, was 23% higher than in the canopy rows. In sites with tramlines, while the number of plants was characterized by relatively even distribution in

TABLE 1. Results of statistical analysis of the features examined

Parameter	Site	Average	Standard deviation	Range	Uniform groups	Difference	Limit value
Number of plants Lr [pc·m^{-1}]	L	45.33	7.26	29	L-S1	1.03	3.418
					L-S2	1.86	
	S1	44.3	4.39	17	S1-S2	0.83	
	S2	43.47	4.52	22			
Number of spikes Lk [pc·m^{-1}]	L	48.27	8.17	36	L-S1	–4.0	4.728
					L-S2	–3.17	
	S1	52.27	7.33	32	S1-S2	0.83	
	S2	51.43	7.5	29			
Grain yield Pz [g·m^{-1}]	L	40.90	7.69	33.1	L-S1	–11.61^{x}	7.021
					L-S2	–10.77^{x}	
	S1	52.52	12.1	44.9	S1-S2	0.84	
	S2	51.68	13.5	47.3			
Grains per spike Lz [pc]	L	28.2	2.39	9	L-S1	–4.47^{x}	2.30
					L-S2	–3.7^{x}	
	S1	32.67	3.92	14	S1-S2	0.767	
	S2	31.9	4.55	17			
Grain mass per spike Pzk [g]	L	0.856	0.078	0.31	L-S1	–0.153^{x}	0.061
					L-S2	–0.137^{x}	
	S1	1.008	0.121	0.47	S1-S2	0.016	
	S2	0.993	0.145	0.51			
Thousand seed weight m.t.n. [g]	L	30.153	1.057	3.5	L-S1	–0.84^{x}	0.564
					L-S2	0.9^{x}	
	S1	30.993	0.975	4.4	S1-S2	0.06	
	S2	31.053	1.251	5.0			

^{x} a statistically significant difference

individual rows after emergence, the differences in the number of spikes in the outer rows (1,2) were due to better tillering of the plants. The productive tillering coefficient value, expressing the ratio of the number of spikes to the number of plants after emergence for crop (L) was, on the average, 1.07, while for sites with tramlines (S1 and S2), it was 1.8 and 1.19, respectively. A comparison of average values for the sites under concern showed no significant differences in terms of the number of plants or spikes (Table 1). However, in sites with tramlines, an increase in the tillering coefficient value was very well visible in rows adjacent to the tramline, amounting to 1.3 for site S1 and 1.33 for site S2.

Apart from the number of spikes, the second component of grain yield is grain mass per spike (Pzk), which amounted to 0.85 on the average in the dense canopy (L). Similar values of this feature were obtained in the internal rows (5 and 6) of both sites with tramlines. In the outer rows, on the other hand (1 and 2), grain mass per spike was 28 to 35% higher. Increase in the grain mass per spike was mainly due to the increase in the number of grains per spike. In the dense canopy, the average number of grains per spike was 28; in spikes of plants growing in rows adjacent to tramline (1 and 2) – it was about 37 pieces, which indicates an increase by about 32% in relation to the canopy; this difference was statistically significant. Changes in the canopy structure were also found in rows located further from the tramline (3 and 4), where the increase in the grain mass per spike and the number of grains per spike was lower, ranging between about 14 and 18%.

Results of the statistical analysis, conducted using the Tukey's HSD test for average values of individual features in the examined sites: the number of plants per 1 m of the row (Lr), the number of spikes per 1 m of the row (Lk), grain yield in 1 m of the row (Pz), number of grains per spike (Lz), thousand seed weight (m.t.n) and grain mass per spike (Pzk) have been presented in Table 1.

As a result of an increase in the number of spikes and the number of grains per spike in rows adjacent to tramlines (1 and 2), an increase in grain yield was observed (Fig. 5). Examining the values presented in this illustration, it can be noted that the highest grain yield (Pz) was recorded in rows 1 and 2 in sites with tramlines, for which the average values were 67.5 $g \cdot m^{-1}$ grain for site S1 and 67.9 $g \cdot m^{-1}$ grain for site S2. In comparison with average yield for the canopy, this constituted an increase by 65.0 and 66.2%, respectively. At the same time, the yield values, presented on the illustration, indicate that sites with tramlines were characterized by much greater ranges of this feature.

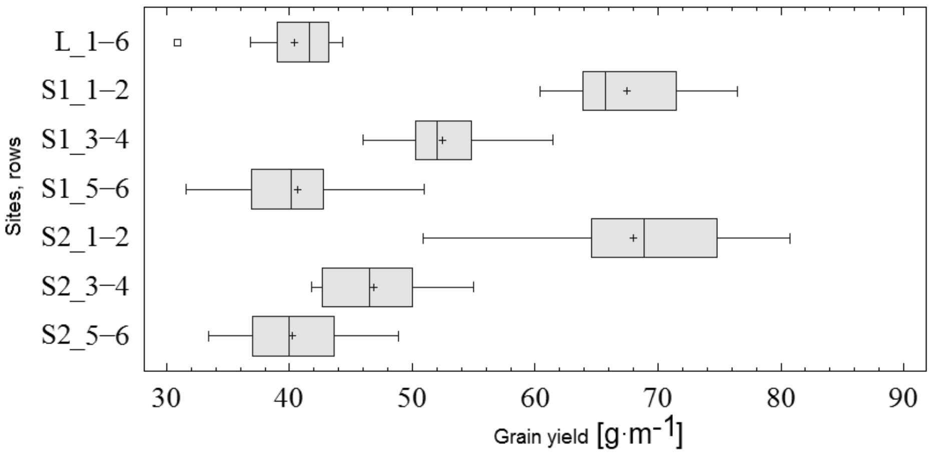

FIGURE 5. Changes in the average value of grain yield (Pz) per 1 m of the row in the sites examined

In rows adjacent to the outer rows (3 and 4) in sites with tramlines, the grain yield values were somewhat lower, amounting to 52.4 $g \cdot m^{-1}$ in site S1 and 46.9 $g \cdot m^{-1}$ in site S2, which, with reference to the canopy, constituted an increase by 28.3% and 14.7%, respectively. The internal rows, farthest from the tramline, generated yield similar to the canopy average.

The research conducted leads to conclusion that increase in the yield of spring wheat in rows adjacent to unsown area amounted to 65–66% in comparison with the canopy and the internal rows. The range of the border effect was still visible in the two subsequent rows adjacent to the tramline; however, it was very weak in the more distant row, in which the plants did not have more space at their disposal, but did have better access to sunlight in comparison with the dense canopy. Similar results for the border effect for spring wheat were obtained by authors of earlier research studies [Buliński and Niemczyk 2015]. A slightly more significant border effect for spring wheat, amounting to 83-84%, was achieved by Niemczyk [1993, 1997] and Gałęzewski et al. [2013].

Analysis of the obtained measurement variables indicates that border effect at the tramline of the width of 32.4 and 43.2 cm can be regarded as identical – no increase was recorded along with increase in the tramline width with regard to the examined features. The above results are largely consistent with those obtained by Rudnicki and Gałęzewski [2008] in research on oats and oat-lupine mix, in which it was found that the border effect increased along with increase in the tramline width up to 37 cm; afterwards, further widening of the tramline was of no significance.

CONCLUSIONS

1. Increasing of the tramline width from 32.4 to 43.2 cm did not influence the border effect in spring wheat.
2. Border effect in rows adjacent to tramlines amounted to 65–66% and was due to increase in the number of spikes in these rows, as well as increase in the number of grains per spike.
3. Border effect was visible in the two subsequent rows of plants adjacent to the tramline.

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Streszczenie: *Wpływ szerokości ścieżki między rzędami roślin na wielkości efektu brzegowego pszenicy jarej*. W pracy przedstawiono wyniki doświadczenia polowego, którego celem było określenie wpływu szerokości ścieżki oddzielającej rzędy roślin na ich efekt brzegowy. W badaniach zastosowano dwie szerokości ścieżki: 32,4 i 43,2 cm. Porównywano plonowanie roślin pszenicy jarej w rzędach brzegowych przy ścieżkach z plonem z rzędów łanu zwartego. Stwierdzono, że zwiększenie szerokości ścieżki w badanym zakresie nie wpłynęło na wielkość efektu brzegowego: wynosił 65% na obiekcie z węższą ścieżką, a zwiększenie szerokości ścieżki do 43,2 cm dało efekt brzegowy 66% w stosunku do łanu. Większe plonowanie ujawniło się w dwóch kolejnych rzędach roślin sąsiadujących ze ścieżką. Efekt brzegowy powstał w wyniku zwiększenia liczby kłosów w rzędach skrajnych i zwiększenia liczby ziaren w kłosie.

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