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Impact of the run path width on yield of winter triticale

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Abstract: *Impact of the run path width on yield of winter triticale.* In a field experiment, under production conditions, yield of winter triticale was examined on plots with varying run path width. Three plots were established with the path between plant rows 21, 36 and 48 cm with, and a control plot (K), established in a canopy with no paths. For each row in individual plot, the following data was gathered: number of spikes, grain mass per spike, grain mass per 1 m of each row and grain mass from repetition plots. The most even measurement results were obtained for the control plot (K) with no run paths. Establishing of a run path, regardless of its width, in all plots led to substantial differentiation of measurement values. The highest values were obtained for rows adjacent to the path. The border effect, calculated on this basis on plots with the path 24 cm wide amounted on the average to 38.3%, with the path 36 cm wide (S2) – 45%, and on land plots with the widest path of 48 cm (S3) – 61%. Higher yields were also recorded in rows next to those adjacent to the path.

Key words: winter triticale, border effect, path width

INTRODUCTION

Intensification of farming and the associated increase in demand for increasingly efficient, larger tools and machines results in the necessity to use large tractors, equipped with wide tires [Brunotte and Sommer 1993]. This brings unfavorable changes in the soil due to its increased compactness, changes in soil pore distribution, causing reduction in porosity, and, in particular, the air content [Buliński and Niemczyk 2007, Błażejczak et al. 2010, Buliński and Sergiel 2013]. Research results [Buliński and Sergiel 2013] indicate that the soil compaction zone, as a result of passage of the tractor wheels, may include the area 30 cm to the side of the wheel track, and the changes include both dilatational and non-dilatational strain. This is most visible in locations of repetitive passages of heavy agricultural machines for soil cultivation, plant treatment and harvesting [Carman 1994, Dawidowski 1995, Grečenko 2003, Nowowiejski et al. 2015].

The run paths, established during sowing, make it possible to treat the plants throughout the entire vegetation period, at the same time reducing the field compaction area and mechanical damaging of plants by the wheels [Braun and Schöne 1973]. In cereal cultivation, paths are established by leaving two or three rows not sown, depending on the width of the tires of the tractor used for treatment purposes. Yield losses due to row number reduction are usually compensated by the so-called border effect. This effect, which consists of surplus plant yield in the rows adjacent to the paths, depends on the plant species [Hadjichristodoulou 1993, Niemczyk 1997, 2002, Niemczyk and Buliński

2012] and path width [Widdowson 1973, Buliński et al. 2015]. Research on wheat [Buliński et al. 2015] and oats [Rudnicki and Gałęzewski 2008] indicates that the scale of the border effect increases along with the path with until a certain limit, after which no significant yield increase is observed in the border rows.

The aim of the research project is to determine to what extent the change in the run path width influences winter triticale yield in the rows adjacent to the path.

MATERIALS AND METHODS

Research was conducted on a production field of a farm, on a soil consisting of light argillaceous sand, with moderately firm substratum. The soil was slightly acidic (pH 5.7), belonging to quality class IVa; agricultural suitability for rye cultivation was good. The soil was well maintained. The forecrop for rye was a spring mix of cereals; after harvesting, a full dose of stable manure was applied. Mineral fertilizers were used prior to sowing in form of a compound fertilizer; nitrogen fertilizer was sown as a top dressing application, in two parts. In the vegetation period, a herbicide was used once, and a fungicide – twice, according to the principles of integrated protection. Temperature levels were close to the average on the many years scale, and it can be assumed that it had no significant impact on the triticale yield. On the other hand, the conditions of plant growth could be more influenced by rainfall. The autumn was dry, which hindered emergence, and the draught in the period between April and July in 2015 resulted in yield reduction. Rainfall, which started in the end of July, did not improve the condition of the winter triticale plantation, as it occurred after the period of the highest plant demand for water.

Qualified seeds of winter triticale of Algoso variety were used for sowing. Spacing between rows was 12 cm. After sowing, three plots were marked on the field (S1, S2, S3) with different path widths (24, 36, 48 cm), and a control plot (K), established in the canopy. In each plot, there were five subplots, each of them 1 m long. Each subplot had the width of six rows and a path located in the middle. Rows 3 and 4 were border rows in relation to the path, and 2 and 5 were adjacent to these. All plots were established within the boundaries of a production field, and the edge rows between subplots 1 and 5 were separated by an intercrop 12 cm wide from other rows in the field. The experimental field diagram has been presented in Figure 1.

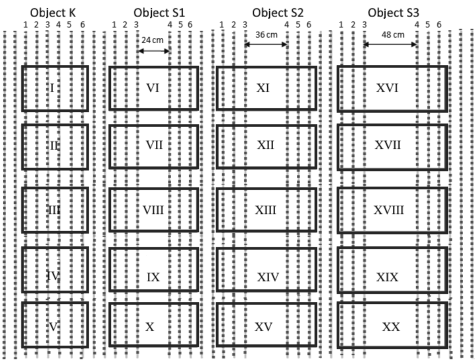

FIGURE 1. The experimental research diagram

Research and observations encompassed all rows within the individual subplots. After the emergence, the number of plants was recorded, and before harvesting – the number of spikes. Plants were harvested separately from each row. After threshing under laboratory conditions, mass and number of grains from 1 m of each row was determined. The above parameters made it possible to calculate the grain mass per spike, the number of grains per spike and grain mass for each subplot.

RESULTS

The basic components of grain harvest include: number of spikes and grain mass per spike, based on the number of grains in the spike and their mass.

The number of spikes from 1 m of a row in the canopy plots was even; on the average, it amounted to 42.7. In plots S1 and S2, the average number of spikes was more than 11% grater, and in plot S3, it was greater by 17% (Fig. 2). On the other hand, there were no significant differences between individual plots with paths (<3%).

At the same time, on the basis of the measurement value distribution, it can be concluded that an increase in the path width led to increasing of the number of rows with a greater number of spikes in 1 m, as well as a substantial dispersion of the values measured. Differences in the number of spikes resulted mainly from greater intensity of plant propagation in the border rows at the plots with paths. The number of spikes in the border rows in the plot with the narrowest path was greater by more than 24% in relation to the canopy, in plot S2 – by about 30%, and in the plot with the widest path – by more than 39%, and it was significantly higher in comparison with the values established for plots S1 and S2. Also in the rows adjacent to the border rows (2 and 5), the number of spikes was significantly higher than in the canopy, within the range of 9–17%.

The grain mass per spike is the second yield component that showed differentiation. Average values of grain mass per spike in individual rows of the plots examined are illustrated by Figure 3.

Analyzing the values presented on the drawing, it can be noticed that the highest uniformity of measurement values was found in the control plot (K), with no paths. Average values of grain mass per spike, established for individual rows from five repetitive fields, were within the range of 1.44–1.50 g, and the average value for the entire control plot (K) was 1.46 g with standard deviation $\sigma = 0.06$, which indicates good uniformity of the control plot.

Establishment of a path, regardless of its width, in all plots led to substantial differentiation of grain mass per spike

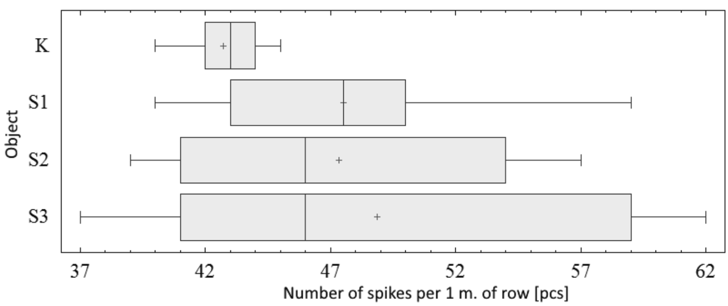

FIGURE 2. Distribution of variability of the number of triticale plant spikes in the experimental plots

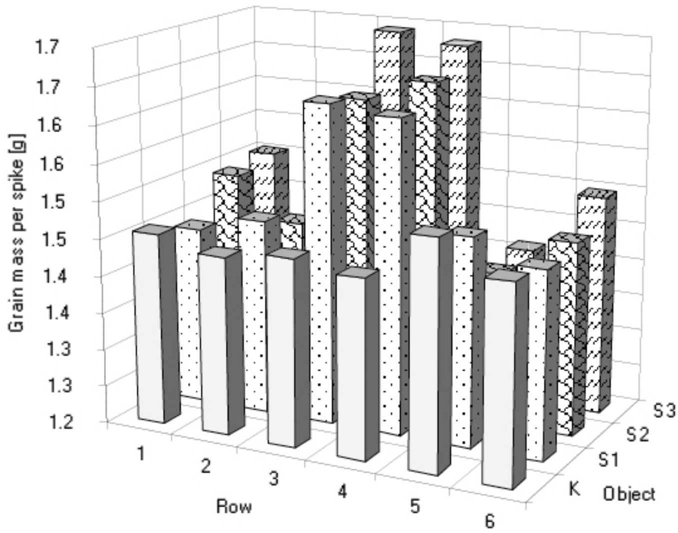

FIGURE 3. Grain mass per spike in winter triticale in individual rows of experimental plots in investigated objects

in individual rows. In plots S1 and S2, the greatest grain mass (1.62 and 1.63 g, respectively) were found in spikes of plants in rows 3 and 4, that is, adjacent to the path. In relation to the average grain mass per spike in the control plot (K) rows, this constituted about 11.7% more.

Further increase in path width to 48 cm (S3) led to a visible increase in grain mass per spike in the rows adjacent to the path (3 and 4). The average grain mass per spike in these rows, amounting to 1.68 and 1.69, was greater by more than 15% in comparison with the plot (K). Grain mass per spike in rows 1 and 2 and in rows 5 and 6 in plots with paths (S1, S2, S3) ranging from 1.41 to 1.50 g was similar to the average value for this parameter 1.41 (1.46 g) determined for plot (K).

Analysis of the entire measurement data using the multiple range tests, Tukey's method HSD 95% confidence level (Table 1), allowed for determination of which rows in individual plots, with regard to grain mass per spike, show statistically significant differences.

The analysis results obtained indicate that in all of the variants examined, plants growing in rows 3 and 4, that is, adjacent to the path, had higher grain mas per spike, differing significantly from the value determined for the control plot.

At the same time, differences between grain mass per spike in the plants from border rows (3 and 4), in most comparisons within and between the plots, were significantly higher in relation to the remaining rows, that is, rows 1 and 2 and rows 5 and 6. No significant differences were also found between the grain yield per spike between edge rows of the plots with paths and the control plot (K).

Triticale yield results in individual rows of the plots examined have been illustrated by Figure 4. The chart values indicate that like in the case of grain

TABLE 1. Matrix of statistical significance of differences in average values of grain mass per spike in individual rows of the plots

		Object/row																	
		S1						S2						S3					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Object/row S1	1			X	X						X					X	X		
	2	-		X	X											X	X		
	3	-	-			X	X					X						X	
	4	-	-	-		X	X					X						X	
	5	-	-	-	-											X			
	6	-	-	-	-	-										X	X		
S2	1	-	-	-	-	-	-												
	2	-	-	-	-	-	-	-			X					X	X		
	3	-	-	-	-	-	-	-	-			X						X	
	4	-	-	-	-	-	-	-	-	-		X	X					X	
	5	-	-	-	-	-	-	-	-	-	-					X	X		
	6	-	-	-	-	-	-	-	-	-	-	-				X	X		
S3	1	-	-	-	-	-	-	-	-	-	-	-	-						
	2	-	-	-	-	-	-	-	-	-	-	-	-	-		X	X		
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-			X	
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			X
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
K				X	X					X	X					X	X		

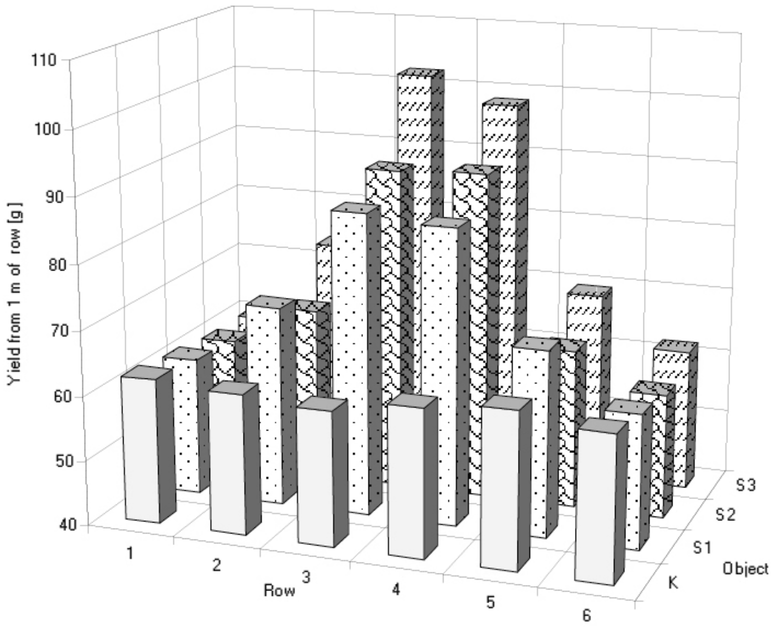

FIGURE 4. Average triticale yield from 1 m of row in individual plots

mass per spike (Fig. 3), grain mass obtained from 1 m of individual rows of the plot (K) were similar (on the average, 62.3 g), while the difference between extreme values (60.7 and 64.0 g) was statistically insignificant. This indicates that under similar growth conditions, individual rows did not differ significantly in terms of the number of plants after emergence. Establishment of a path, in all of the variants analyzed, led to substantial differentiation of yield in rows adjacent to the paths (3 and 4), while edge rows in the plots (1 and 6) gave similar yields (60.7, 61.4 g) as the rows in the control plot. In the plot with the narrowest path (Fig. 5), the average grain yield from 1 m of the rows adjacent to the path (3 and 4) was 85.7 and 86.7 g, respectively, and was higher by more than 38% than the average for the control plot (K).

At the same time, the range of impact of the advantageous border effect encompassed the further rows. Yield from 1 m of rows 2 and 5, adjacent to border rows, was more than 12% higher than the average calculated for all rows from the five repetitive plots of the control plot (K). Statistical analysis of the measurement results showed that differences in the yield of the border rows (3 and 4) and the remaining rows in the plot were highly statistically significant.

Increasing of the width of the path to 36 cm (plot S2) resulted in further increase in the triticale yield in rows adjacent to the paths (Fig. 6) and increased disproportion in relation to the remaining rows.

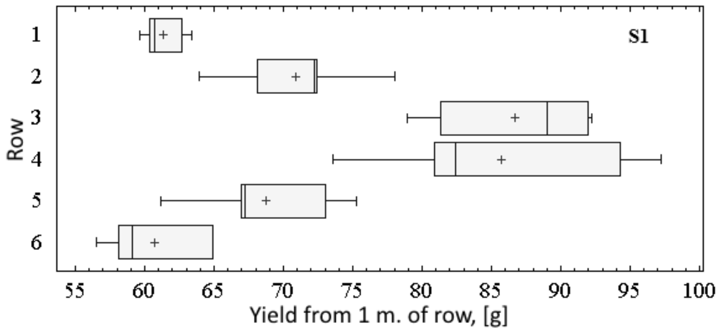

FIGURE 5. Triticale yield variability distribution in individual rows of plot S1

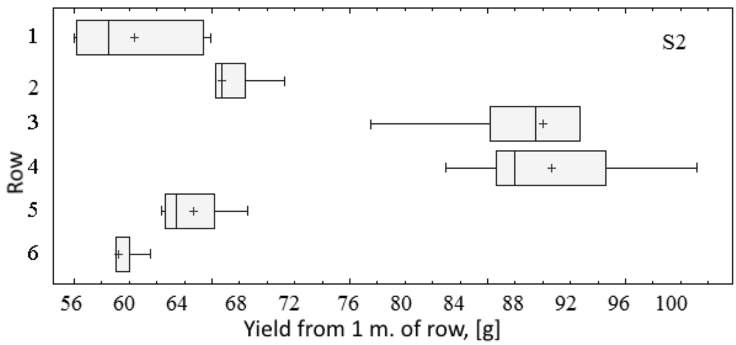

FIGURE 6. Triticale yield variability distribution in individual rows of plot S2

Average yield from 1 m of rows 3 and 4 was 90.4 g, that is, 45% higher than the average yield in the control plot (K). Rows 2 and 5 (adjacent to the border rows) gave somewhat higher yields (by about 10%) than the edge rows 1 and 6. Like in the case of S1, this indicates that the border effect encompasses not only the rows adjacent to the path, but the further ones as well.

Analysis of all measurement results for plot S2 showed that the differences between yields in rows adjacent to the path (3, 4) and the remaining rows were statistically significant. Differences between yields from the remaining rows did not differ in a statistically significant manner at the confidence level of 95%. In plot S3, with the path 48 cm wide (Fig. 7), average yield from the border rows from five plot repetitions amounted to 98.4 and 102.2 g, and it was higher by 61% than the average from the plot (K), and this difference was statistically significant. Rows 2 and 5, adjacent to border rows, gave yields higher by 15% in comparison with the canopy rows, and this difference, although greater than in the remaining plots under concern (S1 and S2), was nevertheless insignificant.

The presented plant yield values for individual rows served as a basis for a comprehensive assessment of the impact of the run path width on triticale yield (Fig. 8). Values presented in the Figure 8 indicate that in the repetitive fields of the plot with no paths (C), the triticale grain yield was the lowest, amounting on the average to 373.7 g. Differences between yields of individual subplots of plot (K) were within 0.3––5.4%. In plots with paths, a significant yield increase was observed. In plots S1 and S2, the average yield from five plots was about 16% higher than in the control plot (K). The highest yield of 466.2 g was recorded in the subplots of S3, and in relation to the plot (K) average, it was higher by 24.7%.

Average yield values from subplot repetitions in individual plots were compared using the multiple range tests method, the Tukey's method HSD 95% confidence level (Table 2).

The analysis conducted indicates that winter triticale grain yield in all plots with paths (S1, S2, S3) was significantly higher in comparison with the control plot (C). Yield from subplots in plots S1 and S2 was similar, while in the plot

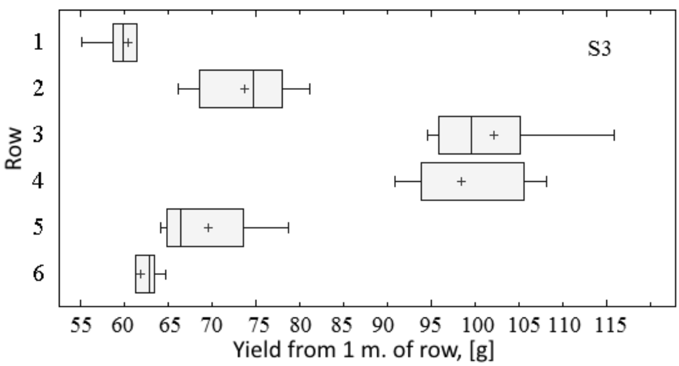

FIGURE 7. Triticale yield variability distribution in individual rows of plot S3

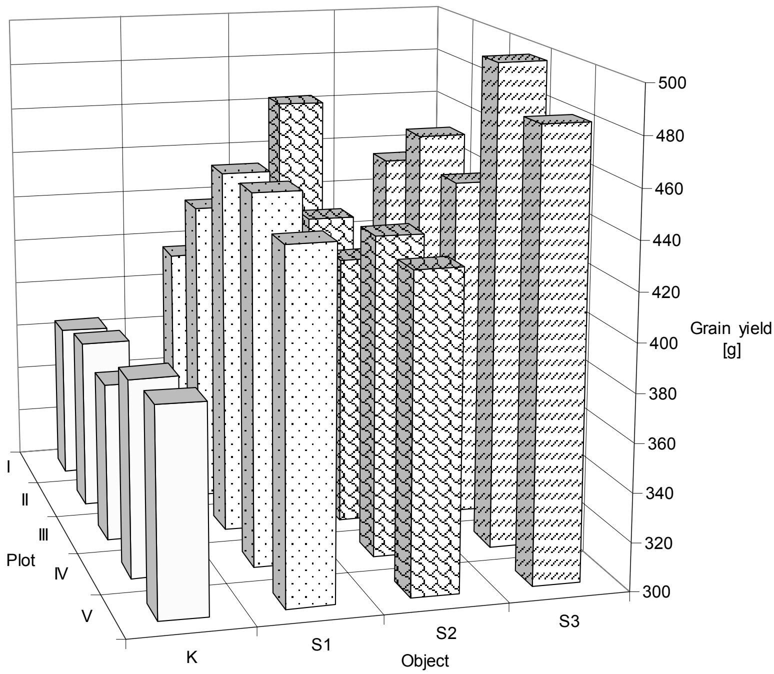

FIGURE 8. Average values of winter triticale yield in individual repetitive subplots of the investigated objects

TABLE 2. Comparison of significance of differences in average yields from individual plots

Object	Mean	Object				+/– Limits
		K	S1	S2	S3	
K	373.74		–60.34*	–57.96*	–92.42*	33.149
S1	434.08	–		2.38	–32.08	
S2	431.70	–	–		–34.46*	
S3	466.16	–	–	–	–	

*Statistically significant difference.

with the widest path it was significantly higher in comparison with the two plots with paths of lesser width.

On the basis of the results obtained, it can be concluded that the path width is a significant determinant that influences the plant yield in the area adjacent to the path. In the plots examined, plants in rows adjacent to the path (3 and 4) gave visibly higher yields both in comparison with other plants in the subplot and with plants from rows in the subplots of the control plot. Increased yield in the plots with paths was due to border effect, which in plot S1 (path of 24 cm) amounted, on the average, to 38.3%, in plot S2 (path of 36 cm) – 45%, and in plot S3 with a path of 48 cm – 61%. In the measurement variants applied, the border effect increased along with the path width.

CONCLUSIONS

1. The research conducted indicated impact of the path width on yield of winter triticale in the zone adjacent to the path. Border effect was created by increase in the number of spikes per 1 m of a row and increase in grain mass per spike.
2. The number of spikes per 1 m of rows adjacent to the paths in the plot with the narrowest path was more than 24% greater in comparison with the canopy, in the plot with the path 36 cm wide – it was greater by 30%, and in the plot with the path 48 cm wide, it was more than 39% greater.
3. In plots with paths, the highest grain mass was obtained from spikes of plants growing in the edge rows. Adjacent to paths 24 and 36 cm wide, the average grain mass per spike was higher by 11.7% in comparison with the canopy, and in the plot with the path 48 cm wide, it was higher by more than 15% in comparison with the canopy.
4. Border effect for the path widths examined (24–48 cm) increased along the width. In the plot with the narrowest path of 24 cm, average grain yield per 1 m of rows adjacent to the path was 38.4% greater in comparison with the canopy average, in the plot with a path 36 cm wide, the yield of grain from 1 m of rows adjacent to the path was higher by 45% in comparison with the average canopy yield, and in the plot with a path 48 cm wide, it was higher by 61%.
5. The highest grain yield was recorded in plots with the widest path; it was greater on the average by 24.7% in comparison with the canopy.

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Streszczenie. *Wpływ szerokości ścieżki przejazdowej na plonowanie pszenżyta ozimego.* W doświadczeniu polowym, w warunkach produkcyjnych badano plon pszenżyta ozimego w obiektach z różną szerokością ścieżki przejazdowej. Wyznaczono trzy obiekty o szerokościach ścieżki oddzielającej rzędy roślin: 21, 36 i 48 cm, oraz obiekt kontrolny (K), utworzony w łanie bez ścieżek. Dla każdego rzędu w poszczególnych obiektach oznaczono: liczbę kłosów, masę ziarna w kłosie, masę ziarna z 1 m rzędu i masę ziarna z poletek powtórzeniowych. Największym wyrównaniem wartości pomiarowych odznaczał się obiekt kontrolny (K) bez ścieżek. Założenie ścieżki przejazdowej, bez względu na jej szerokość, we wszystkich obiektach prowadziło do znacznego zróżnicowania wartości pomiarowych. Największe wartości otrzymano dla rzędów zlokalizowanych bezpośrednio wzdłuż ścieżki. Obliczony na tej podstawie efekt brzegowy na poletkach ze ścieżką o szerokości 24 cm (S1) wyniósł średnio 38,3%, ze ścieżką 36 cm (S2) – 45%, a ze ścieżką 48 cm (S3) – 61%. Stwierdzono również większe plonowanie roślin w rzędach położonych obok sąsiadujących ze ścieżką.

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