Abstract: Edge effect in winter rape cultivation technology with traffic paths. There are presented results of a 3-year field experiment aimed at determination of winter rape yielding in the rows adjacent to traffic paths in comparison with the rows of compact plant field. The edge effect of 61.5% was found, resulted from considerably higher number of siliques on plants next to paths. A decrease in yield from unsown path area was considerably compensated due to the edge effect.

Key words: winter rape, traffic paths, edge effect, edge row, yield compensation.

INTRODUCTION

Operations in plant cultivation technologies mainly aim at providing the most favourable conditions for plants’ growth, development and yielding, with consideration to their specific needs and environmental factors. Although the needs of a given crop can be considered as constant, the external factors vary continuously; there are introduced new solutions to machines and implements changing their technological abilities, the soil-climatic conditions change (precipitation, temperature, soil state). One can find in references the values of particular soil parameters that are most favourable for particular crops with respect to their needs [Dziensia 2000]. Modern plant cultivation systems are more and more focused on operational effectiveness, by introduction of precise methods for cultivation, fertilizing and plant protection with application of traffic paths. As it is evident from numerous references related to crop cultivation with traffic paths, such system of vehicles’ field traffic enable to reduce soil compaction [Domsch 1993; Buliński and Niemczyk 2003, 2007, 2009; Buliński and Marczuk 2007], it improves availability of nutrients [Febo et al. 2003].

Research results prove that elimination of 2 or 3 plant rows in the place of traffic path is compensated by an increased plant yield in the edge rows (so called edge effect. The yield increase reported in investigations on cereals ranged to 60–113% [Austin and Blackwell 1980; Braun 1978; Braun 1980; Niemczyk 1996; Widdowson 1973] and for sugar beets it ranged to 31–45% [Brunotte and Sommer 1993; Buliński and Niemczyk 2003]. However, Hadjichristodoulou [1993] reported a very wide range of edge effect for cereals, rape and sunflower from 1% to 384%, depending on variety, place and watering.

The rape cultivation calls for multiple operations within a vegetation period connected with top dressing, plant protection against weeds and pests, and prior to harvest the yield protection against grain losses at header. An intensive cultivation calls for application of traffic
paths, especially at narrowed inter-row distances.

The reference data on rape yield in cultivation with traffic paths are scarce. Therefore, these investigations aimed at finding out, if and how a decreased number of plants per field unit area resulted from introduction of traffic path system can be compensated by so called edge effect, and how big is winter rape yield increase in the edge rows next to the paths.

MATERIAL AND METHODS

The investigations were carried out for three years on winter rape plantations on degradated black earth made of light boulder clay of fluming content about 20%, under regular water conditions and a medium humus content at pH 6.6, and soil valuation class IV. The experiment was set up with the method of long plots of length 30 m. The two objects were investigated: A – compact plant field with no passages, and B – the object with traffic paths for running the outfits during fertilizing and plant protection. Each object consisted of five measuring plots of length 1 m and width corresponding to 7 plant rows (Fig. 1). The winter rape was sown in rows spaced about 22 cm, while width of a single traffic path (Fig. 1B) amounted to about 66 cm and resulted from disengagement of 2 coulters of the drill. In the object with traffic paths the rows I, II and VI, VII were adjacent to the paths.

As a result of this set up, the field area per one plant in the edge row in traffic path object was almost twice bigger (433 cm²) than in compact plant object (218 cm²).

Within the period from seeding to harvest, the outfits for mineral fertilizing (Ursus C330 + mounted spreader RCW of overall mass about 2800 kg) and for chemical plant protection (Ursus C330 + mounted sprayer 400 l and overall mass about 2900 kg) were running on the paths. The working width of both outfits amounted to 8 m. During vegetation period five operational runs of mineral fertilizing and plant protection were executed on the paths (one in autumn and the remaining ones starting from spring). The plants were collected from each row separately from particular plots. There were determined the following: rape yield per 1 m of row, number of plants in each row, number of siliques per plant, number of branches per plant, number of seeds per silique and mass of 1000 seeds.

FIGURE 1. Layout of measuring arrangement: Ł – compact plant plot, S – traffic path plot
The presented investigations sum up experiments carried out in years 2001/2002, 2003/2004, 2005/2006 on the effect of multiple running of tractor outfits over the field in the winter rape vegetation period, as well as the effect of cultivation system on changes in plant development conditions. The specification of climatic and agro-technical conditions, changes in soil compaction and soil air-water conditions in investigated vegetation seasons were presented in previous works of the authors [Buliński and Niemczyk 2007, 2009].

RESULTS OF INVESTIGATIONS

The rape yield is connected with number of plants per unit area and quantity of seeds per single plant. The latter results from number of siliques per plant, number of seeds per silique and the mass of 1000 seeds. This work presents analysis of these yield structure elements together with their impact on the edge effect.

The number of plants in particular rows are presented for particular years (Fig. 2). The analysis showed slightly higher values for the object with compact plants in all investigated years, however, these differences were not significant. In both objects they varied naturally in particular rows and years, and number of plants ranged from 8 to 13, while in the object with traffic paths from 6 to 12. No distinct nature of changes in number of plants depending on number of row (next to path or in the middle of plot) was found.

FIGURE 2. Number of plants in particular rows of the objects: a – with compact plants (L1–L3), b – with traffic paths (S1–S3)
Number of siliques per plant in particular rows is presented in Figure 3. Considering the presented results one can find a distinctly bigger values for particular plants in rows next to paths, i.e. I–II and VI–VII (Fig. 3b). Number of siliques on plots with compact plants averaged to 85, while on plots with traffic paths to 119, however, this parameter varied greatly. The value range for the object with compact plants amounted to 42.6, while for the object with traffic paths to 99.6. In rows next to paths the number of siliques was 45.3–85.3 bigger than on the plants in corresponding rows of compact plants and averaged to 141 for the years. In middle rows (III–V) the objects with traffic paths showed bigger values by about 4–8%. The significantly higher number of siliques in edge rows results probably from a bigger area and better lighting. It is confirmed by data connected with number of branches on particular plants (Fig. 4).

The results for plots with traffic paths were similar to that obtained for number of siliques. The plants in rows next to paths had by about 31–48% more branches than the middle rows (III–V), but were similar to plants in rows on the plots with compact plants. The number of branches in compact plants amounted to 3.1–5.3, while on the object with paths it amounted to 3.4–8.9 (averaged for particular rows on five plots of each object). The statistical analysis proved that number of branches in the rows next to paths was significantly bigger ($\alpha = 0.95$) than that for middle rows of traffic path object and for all rows of compact plant object.

The rape yield depended also on the silique filling with seeds, which was not

![Figure 3](image-url)
significantly different for both objects. No significant differences in number of seeds per silique were found: it averaged to 15.1 for compact plants and to 15.4 for traffic path object, with the range 10.3–10.4 and 19.3–19.4, respectively (Fig. 5).

Similarly to previous presented factors, mass of 1000 seeds was not significantly different in particular rows of the objects. The above elements shaped the yield in each row on the plots. The winter rape yield per 1 meter of row in the object with traffic paths is presented in Figure 6 as average mass of seeds in particular rows and years of experiment. One can find that distribution of yield is different for both objects: it was not connected with a specific row in the object with compact plants, where average yield amounted to 46.52–65.8 g/m (average (55.9 g.m). The similar yield was found in middle rows (III–V) of the traffic path object (Fig. 6b), where it amounted to
57.9 g/m. No statistically significant differences in average yield were found at significance level 95%, when the values for both objects were compared.

The seed yield in the object with traffic path was different (Fig. 6b); it was included in the range of 48.9–113 g/m, with average value for the entire object amounted to 75.82 g/m. The least yield values were found in middle rows of the object with traffic paths (similar to that of compact plants); it did not exceed 66.2 g/m (almost half of maximal value in the row next to path – 113.3 g/m). The increased yield in edge rows did not influence the total yield for the object. Comparing the edge rows (I, II, V, VI) in traffic path object with that of compact plant object (Fig. 7) the more uniform yield in the latter object was found; it ranged to 64.36–113.3 g/m (average for edge rows of 3 years was equal to 90.1 g/m and was close to a median value – 89.1 g/m). It proved its uniformity in particular rows.

The edge effect in rows next to paths amounted to 61.5%. The increased yield in these rows results from significant growth of siliques on the plants. This is consistent with reference data, which report that number of siliques is highly variable and is a basic yield-generating element of winter rape [Wielebski 2007; Wojtowicz 2005].

The traffic path technology can lead to decreased area under plants, therefore, a certain decrease in the yield can
be expected. Basing on obtained results a theoretical yield of winter rape yield was calculated in seeding with traffic paths (with two unsown rows and spacing 22 cm). At inter-path distance of 8 m, the unsown area amounts to 10.3% and a decrease in yield is equal to 3.7%. At inter-path distance of 24 m, the unsown area amounts to 3.6% and the yield decrease 1.3%; therefore, the edge effect considerably compensates the yield loss.

CONCLUSIONS

1. The carried out investigations showed a distinct and statistically significant edge effect in the plants in rows next to the traffic path on winter rape yield.
2. The yield in rows next to paths was higher by 61.5% than that on the compact plant plot.
3. The number of siliques per plant was a decisive factor for the edge effect in winter rape cultivation.
4. The yield losses from unsown area of traffic paths were considerably compensated due to the edge effect.

REFERENCES


FEBO P., PESSINA D., VALLONE M. 2003: Soil-tyre/track interaction. A review of the last ten years of studies from the soil compaction point of view. Rivista di Ingegneria Agraria, Vol. 34, nr 3, s. 55–68.

HADJICHristodoulou A. 1993: Edge effects on yield, yield components and other physiological characteristics in cereals and oilseed crops. J. Agric. Sci., Camb. 120: 7–12.


Streszczenie: Efekt brzegowy rzepaku ozimego w technologii ze ścieżkami przejazdowymi. W pracy przedstawiono wyniki 3-letniego doświadczenia polowego, którego celem było określenie plonowania rzepaku ozimego w rządach sąsiednich z przejezdami w porównaniu do rządów łańcu. Uzyskano efekt brzegowy w wysokości 61,5%, a wynikał z istotnie wyższej liczby łuszczyn związanych na roślinach przy ścieżkach. Dzięki efektowi brzegowemu spadek plonu z nieobsianej powierzchni ścieżek został znacznie wyrównany.

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