THE EFFECTS OF DIFFERENT TILLAGE METHODS AND WEED CONTROL STRATEGIES ON THE YIELD OF WINTER OILSEED RAPE

Vliv různých způsobů zpracování půdy a strategií regulace zaplevelení na výnos ozimé řepky

Mateusz SOKÓLSKI, Krzysztof J. JANKOWSKI, Bogdan DUBIS
University of Warmia and Mazury in Olsztyn, Poland

Summary. This article presents the results of a study evaluating the effect of different weed management strategies on the yield of winter oilseed rape under various tillage systems. The experiment was conducted in 2016-2018 in the Agricultural Experiment Station in Bałcyny owned by the University of Warmia and Mazury in Olsztyn. The yield of winter oilseed rape was highest in the strip-till treatment. In ploughed and no-till treatments, seed yields were 0.16 and 0.29 t/ha lower, respectively. In strip-till and no-till treatments, the use of herbicides with different mechanisms of action (soil, foliar and sequential application) did not induce significant variations in seed yield. In the ploughed treatment, winter oilseed rape yield peaked when the herbicide was applied immediately after seeding. In this system, the foliar and sequential application of herbicides decreased seed yield by 0.41 and 0.13 t/ha, respectively.

***Keywords**: rapeseed, regulations of weeds, no-till farming, strip-till, tillage, yield, tillage system*

Souhrn: V rámci tohoto článku jsou publikovány výsledky studie, která hodnotí vliv různých strategií regulace zaplevelení u řepky ozimé, založené na pozemcích s různým zpracováním půdy. Experiment probíhal v letech 2016-2018 na výzkumné stanici zemědělské v Bałcyny, která spadá pod univerzitu Warmia a Mazury ve městě Olsztyn. Nejvyšších výnosů dosahovaly porosty, kde byla půda zpracována strip-till technologií. V případě využití orby a při nezpracování půdy se výnosy semen snížily o 0,16 a o 0,26 t/ha. V případě strip-till technologie a technologie bez zpracování půdy nebyly zjištěny signifikantní rozdíly mezi jednotlivými způsoby aplikace herbicidů (aplikace na povrch půdy, aplikace na list a dělená aplikace). V případě orebního zpracování půdy dosahovala řepka ozimá nejvyšších výnosů v případě, že aplikace herbicidů proběhla bezprostředně po výsevu. V rámci tohoto systému zpracování půdy snížila aplikace herbicidů na list a dělená aplikace herbicidů výnos o 0,41 a 0,13 t/ha.

***Klíčová slova**: ozimá řepka, regulace zaplevelení, bezorebné technologie, strip-till, orba, výnos*

Introduction

In the cultivation of winter oilseed rape and other crops, seed yield is determined by various factors, including weather and environmental conditions, and agricultural intensity (Chiriac et al., 2013). Tillage is the main agronomic factor in the production of winter oilseed rape because it influences soil properties, plant health and the decomposition of preceding crop residues after harvest (Šařec et al., 2008). Tillage also affects plant emergence and development (Ozpinar and Cay, 2006) by promoting optimal soil aeration and moisture content (Romaneckas et al., 2011)

Conventional plouging often leads to deterioration in soil properties (Kertesz and Madarasz, 2014). Ploughs turn over and loosen soil, thus increasing its aeration and contributing to water loss (Guan et al., 2015). For this reason, direct seeding is applied in many countries. However, this system often decreases the yield and productivity of oilseed rape (Khakbazan and Hamilton, 2012).

Simplified tillage systems exert a less disturbing effect on the vertical soil profile. Post-harvest residues are not completely removed from the field, and they exert various effects on the biological, chemical and physical properties of soil (Morris et al., 2010). Strip-till is an increasingly popular soil management technique which combines the advantages of several cultivation systems. In comparison with conventional tillage, strip-till enhances soil properties and improves the profitability and efficiency of oilseed rape production (Fernández et al., 2015).

Numerous research studies have demonstrated that despite their advantages, simplified tillage systems may contribute to weed infestation (Blecharczyk et al., 2011) and, consequently, may decrease crop yields (Rieger et al., 2008). For this reason, weed management strategies should be adapted to the specific requirements of a given tillage system (Witkowski, 1998).

Weed species that appear in the field already in the fall (*Viola arvensis, Matricaria maritima, Stelaria media, Galium aparine, Thlaspe arvense, Capsella bursa-pastoris*) pose the greatest problem in the production of winter oilseed rape (Praczyk, 2005). Weed management is critical to achieving high crop yields. For this reason, several weed control methods should be combined, beginning from soil cultivation to the direct elimination of weeds. Reduced tillage systems are increasingly applied in the production of oilseed rape, which increases weed pressure (Mrówczyński et al., 2009). Weed control strategies are influenced by the tillage method as well as weather conditions, weed abundance and the presence of persistent weeds (Martin et al., 2001), plant health and seeding date (Martin et al., 2001).

Materials and Methods

Winter oilseed rape (Kuga F_1) was grown in a field experiment in 2016-2018 in the Agricultural Experiment Station in Bałcyny (latitude 53°35′42″ N, longitude 19°51′20″ E, NE Poland). The experiment had the following design:

- three tillage and seeding treatments:

(A) strip-till,

(B) no-till,

(C) ploughing, and

- three weed control strategies:

(a) Butisan Star Max 500 SE (2.5 l/ha) applied to soil 0-2 days after seeding,

(b) Navigator 360 SL (0.3 l/ha) + Metazanex 500 SC (1.5 l/ha) applied to the leaves in BBCH stages 12-14,

(c) Command 480 EC (0.15 l/ha) applied 0-2 days after seeding + Navigator 360 SL (0.3 l/ha) applied in BBCH stages 12-14 (applied sequentially to soil and leaves).

The experiment had a randomized complete block design with three replications. Plot size was 15 m^2 (10 m × 1.5 m). Each year, the experiment was established on Haplic Luvisol developed from boulder clay (IUSS, 2006). The soil had a slightly acidic pH ranging from 5.37 to 5.90 in 1 mol/L KCl. Soil nutrient levels were as follows: 1.04–1.28% C_{org} (Kurmies method), 39.8-68.4 mg/kg P (Egner-Riehm method), 120.1-124.5 mg/kg K (Egner-Riehm method), 54-78 mg/kg Mg (atomic absorption spectrometry, AAS, Carl Zeiss Jena, Germany), 4.4-13.3 mg/kg SO_4^{2-} (UV - 1201V spectrophotometer, Shimadzu Corporation Kyoto, Japan), 2.1-3.7 mg/kg Cu (AAS), 5.6-11.8 mg/kg Zn (AAS), 128-155 mg/kg Mn (AAS), and 1680-2000 mg/kg Fe (AAS).

Winter wheat was the preceding crop. Winter oilseed rape was sown between 10 and 20 September at 50 germinating seeds per m^2. Before seeding, all treatments were fertilized with 40 kg N, 60 kg P_2O_5 and 120 kg K_2O per ha. In the fall, monocotyledonous weeds were controlled with Agil-S (0.7 l/ha). Caryx 240 SL herbicide (1 l/ha) was applied at BBCH 14. Spring fertilization consisted of 240 kg N/ha (120 kg N/ha at BBCH 20 + 100 kg N/ha at BBCH 50) and 80 kg S/ha at BBCH 20. Foliar boron fertilizer was applied twice in the spring. Toprex 375 SC (0.5 l/ha) was applied at BBCH 30-31, and Pictor 400 SC (0.5 l/ha) was applied at BBCH 65. Pesticides were applied when economic thresholds had been exceeded. Data were analyzed by ANOVA, and treatment means were compared by Duncan's test at a probability level of 0.05 in Statistica 13.1 PL.

Results and Discussion

Jaskulska et al. (2014) did not report significant differences in the habit of winter oilseed rape plants grown in tilled treatments and in no-till treatments with a seeding depth of 20 or 10 cm. The plants produced main stems with a length of 120-124 cm and around 5.7-5.9 side branches. The number of siliques per plant (89-94), the number of seeds per silique (20-21) and 1000-seed weight (4.29-4.37 g) were similar across the analyzed treatments. In a study by Budzyński et al. (2000), ploughing (to a depth of 18 cm), shallow ploughing (10 cm) and ploughless tillage (10 cm) did not induce significant differences in the yield components of winter oilseed rape. Regardless of the applied tillage method, the number of yielding plants was determined at 61-67 plants/m^2, the number of seeds per silique – at 25-27, and 1000-seed weight – at 3.74-3.80 g. However, the number of siliques per plant differed across treatments, and it was highest (62.6) in the treatment with conventional tillage in the fall and lowest (51.5) in the ploughless tillage treatment. In the present study, the strip-till treatment was characterized by the tallest plants with the highest number of side branches. The shortest plants with a significantly lower number of side branches were produced in the treatment with conventional tillage in the fall (Table 1). Weed control did not exert a significant effect on the canopy architecture of winter oilseed rape (Table 1).

In a study by Orzech et al. (2014), seed yield was similar in the treatment where skimming and harrowing were followed by ploughing to a depth of 20 cm and in the treatment with single ploughing to a depth of 30 cm. Seed yield decreased significantly by up to 10% in the treatment where skimming to a depth of 10 cm was followed by harrowing. In an experiment performed by Jaskulska et al. (2014), the yield of winter oilseed rape was highest (3.35 t/ha) in response to ploughing. Yield was reduced by 0.26 t/ha in the no-till system with a seeding depth of 20 cm, and it was further reduced to 0.33 t/ha in the ploughless treatment with a seeding depth of up to 10 cm. Chiriac et al. (2013) demonstrated that the yield of winter oilseed rape was negatively correlated with reduced tillage, but was influenced by environmental conditions and agronomic factors. According to Romaneckas et al. (2011), precision seeding after simplified tillage may or may not lead to a minor decrease in yield. In our study, seed yield was highest (6.45 t/ha) in the strip-till system. The yield of winter oilseed rape grown in ploughed and no-till treatments was lower by 0.16 and 0.29 t/ha, respectively (Table 2).

Table 1. The effects of tillage and seeding method and weed control strategy on the yield components of winter oilseed rape.

Weed control	Tillage and seeding method			Average for weed control
	A	B	C	
Plant height (cm)				
a	132.98	126.37	124.43	127.93
b	134.32	130.53	125.28	130.04
c	135.27	129.55	124.25	129.69
Average for tillage and seeding method	134.19[a]	128.82[ab]	124.66[b]	—
Stem thickness (mm)				
a	12.38	10.94	16.56	13.29
b	11.53	10.79	10.01	10.78
c	14.00	10.77	9.78	11.51
Average for tillage and seeding method	12.64	10.83	12.12	—
Height of the first side branch (cm)				
a	43.77	45.80	59.59	49.72
b	48.18	47.20	54.01	49.80
c	48.29	42.16	53.82	48.09
Average for tillage and seeding method	46.75[b]	45.05[b]	55.80[a]	—
Number of side branches				
a	7.48	5.90	5.00	6.13
b	7.05	5.63	4.18	5.62
c	6.87	5.78	4.77	5.81
Average for tillage and seeding method	7.13[a]	5.77[b]	4.65[c]	—
Length of the first side branch (cm)				
a	62.13	55.18	46.80	54.70
b	56.98	57.82	49.18	54.66
c	59.84	59.70	47.80	55.78
Average for tillage and seeding method	59.65[a]	57.57[a]	47.92[b]	—
Stand height at harvest (cm)				
a	123.00	115.13	96.96	111.69
b	125.13	117.13	106.71	116.32
c	124.54	118.46	105.75	116.25
Average for tillage and v method	124.22[a]	116.90[b]	103.14[c]	—

a, b, c denote homogeneous groups, P≤0.05

In the work of Franek (2001), oilseed rape yield was highest when herbicides were applied at BBCH 11-12 or immediately after seeding. Delayed herbicide application at BBCH 14-16 decreased seed yield by approximately 0.25 t/ha. In the current study, the application of herbicides with different mechanisms of action improved the yield of winter oilseed rape only in the ploughed treatment. In the conventional (ploughed) tillage system, seed yield peaked when herbicides were applied directly after seeding. Foliar and sequential herbicide application in the ploughed treatment decreased seed yields by 0.41 and 0.13 t/ha, respectively. All of the tested herbicide combinations were equally effective in no-till and strip-till treatments.

Table 2. The effects of tillage and seeding method and weed control strategy on the yield components of winter oilseed rape

Weed control	Tillage and seeding method			Average for weed control
	A	B	C	
Number of plants per m^2				
a	29.78	29.10	29.51	29.46
b	29.26	27.65	29.71	28.87
c	29.69	29.02	30.29	29.67
Average for tillage and seeding method	29.58	28.59	29.84	—
Number of siliques per plant				
a	157.28	161.82	168.88	162.66^{b}
b	179.03	184.87	176.22	180.04^{a}
c	155.60	165.21	170.41	163.74^{b}
Average for tillage and seeding method	163.97	170.63	171.84	—
Number of seeds per silique				
a	28.27	25.75	24.58	26.20
b	25.30	24.75	22.90	24.32
c	27.78	25.90	23.62	25.77
Average for tillage and seeding method	27.12^{a}†	25.47^{b}	23.70^{c}	—
1000-seed weight (g, 87% DM)				
a	5.35	5.57	5.81	5.58
b	5.37	5.33	5.56	5.42
c	5.52	5.51	5.72	5.57
Average for tillage and seeding method	5.41^{c}	5.47^{ab}	5.70^{a}	—
Seed yield (t/ha, 87% DM)				
a	6.44	6.14	6.47^{a}	6.35
b	6.47	6.13	6.06^{b}	6.22
c	6.44	6.22	6.34^{ab}	6.33
Average for tillage and seeding method	6.45^{a}	6.16^{b}	6.29^{ab}	—

a, b, c denote homogeneous groups, P≤0.05

Conclusions

The yield of winter oilseed rape was highest in the strip-till treatment. Yields were lower by 0.16 and 0.29 t/ha in ploughed and no-till treatments, respectively.

In the conventional (ploughed) tillage system, the yield of winter oilseed rape peaked when herbicides were applied directly after seeding. All of the tested herbicide combinations were equally effective in no-till and strip-till treatments

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Kontaktní adresa

Mateusz Sokólski, Department of Agrotechnology, Agricultural Production Management and Agribusiness, University of Warmia and Mazury in Olsztyn, Oczapowskiego 8, 10-719 Olsztyn, Poland, e-mail: mateusz.sokólski@uwm.edu.pl