2009 vol. 70, 111-123
DOI: 10.2478/v10032-009-0011-1

GROWTH AND YIELDING OF ONION UNDER CONSERVATION TILLAGE*

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Received: July 8, 2008; Accepted: November 16, 2008

Summary

A field experiment with conservation tillage was set up to study the effect of using cover crops: spring rye (*Secale cereale*) and vetch (*Vicia sativa*), and various methods of soil preparation prior to sowing: no-tillage, rotary disk ploughing in the spring, and pre-winter disk ploughing, on the growth and yielding of onion cv. Wolska as compared with conventional cultivation methods.

Sprouting of onion plants was best on those plots where spring rye mulch had been mixed with the soil during pre-winter disk ploughing. Mixing the soil with the biomass of vetch by disk ploughing in the spring reduced the extent of sprouting. Growth of onion plants was best following traditional soil cultivation. On those plots, onion plants were the tallest and produced the most leaves. The soil conservation factor employed by taking advantage of the mulching effect of intercrop plants of spring rye and vetch was found to reduce the total and marketable yields of onion in comparison with traditional cultivation. The most beneficial pre-sowing tillage method for onion was traditional tillage consisting in pre-winter ploughing and soil preparation treatments in the spring, without the presence of a mulching crop. Among the soil mulching plants under comparison, a more beneficial effect on onion yields was produced by the spring rye. As far as conservation tillage is concerned, the best effects were obtained following spring tillage in which rye mulch was mixed with the soil by disk ploughing.

key words: conservation tillage, cover crops, vetch, rye, onion, yield

INTRODUCTION

Economic and environmental conditions, and the growing consumer demands, make the world agriculture look for even better, pro-ecological cultivation methods. For many years now, attempts have been made to depart from the

* The work was carried out as part of Research Project No. 2PO6R 060 26 financed by the Ministry of Science and Higher Education

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classical system of soil cultivation in favour of reduced tillage or even no tillage. The shortage of manure, shorter crop rotation times and intensification of production have caused alternative methods of organic fertilization and ways of increasing organic matter content in the soil to acquire special significance. Conservation tillage of the soil combines the economic aspect with the protection of the soil environment. It is defined as a cultivation method that makes use of mulching in order to protect the soil from degradation and to maintain its fertility (Zimny 1999).

In conservation tillage, sowing is most often carried out directly into the frozen-through or desiccated green mulch, or else organic matter is mixed with the soil by shallow ploughing. According to American standards, to be able to talk about conservation tillage, at least 30% of the soil surface must be covered with organic remains (Rasmussen 1999, Shrestha *et al*. 2006). Conservation tillage is used in integrated and ecological agriculture, and in good agricultural practice (Kuś 1995, Zimny 1999). The cover of green mulch on the soil surface prevents water and wind erosion and soil encrustation, improves water infiltration and retention, reduces water evaporation from the soil, decreases nitrogen losses in winter, controls weed infestation, while the mixing of the plant biomass with the soil has a beneficial effect on the structure, interaction with water and air, and biological activity of the soil (Höppner *et al*. 1995, Teasdale & Mohler 2000, Nyakatawa *et al*. 2001, Willumsen & Thorup-Kristensen 2001, Parker *et al*. 2002).

Because of a shallow root system and a relatively short growing period, the onion is very demanding in terms of nutrition and soil quality, which means that yields can fall within a wide range depending on the cultivation conditions (Gruszecki & Tendaj 2001, Felczyński 2002). It requires a well-prepared field, especially when grown from seeds that are sown directly into the ground (Rumpel 2003, Adamicki *et al*. 2005). For that reason, cultivation of onion by sowing under the conditions of conservation tillage runs up against many difficulties and is not as common as in other plant species. The aim of the experiment presented here was to assess the effect of conservation tillage with intercrop cover plants on the growth and yielding of onion.

MATERIALS AND METHODS

The field experiment was carried out in 2004-2006 at the Experimental Station Felin of the University of Life Sciences in Lublin, on a podsolic soil formed from medium, dusty clay. At the beginning of the onion vegetation period, the organic matter content in the soil ranged from 2.00 to 2.36%, and the pH value from 5.5 to 6.0. In the arable layer (0-20 cm), the soil was analyzed to contain on average: 12.1-14.0 mg P, 14.6-22.3 mg K, and 7.2-10.3 mg Mg·100 g^{-1} of soil. The experimental plant was the common onion (*Allium cepa* var. *cepa* Helm.) cv. Wolska.

The design of the experiment, set up using the random sub-block method in 4 replicates, included two cover crops for mulching: spring rye (*Secale ce-*

reale) and vetch (*Vicia sativa*), and various soil tillage methods: A) no tillage prior to sowing, B) disk ploughing in the spring, C) disk ploughing in the autumn. The cover plants: spring rye at 150 kg·ha^{-1} and vetch at 140 kg·ha^{-1}, had been sown towards the end of July 2003, and in the first week of August 2004 and 2005, in the years preceding the growing of onion. The biomass that had been produced (from 8.8 to 34.8 t f.w. of vetch, and from 17.0 to 39.1 t f.w. of rye per ha) was mixed with the soil according to a pre-determined plan (in the autumn or in the spring). During the winter, the intercrop plants left in the field were affected by frost, and in the spring the soil was covered with mulch. The tillage combinations used are shown in Table 1.

Table 1. Sequence of treatments in the soil tillage systems used for growing onion in the experiment

K – Traditional ploughing without cover crops	LJ: 1+2+2+5; W: 2+7+8+2+9+2
A – Cultivation with sowing of cover aftercrops; direct sowing of onion (no tillage)	LJ: 3+2+4+2: W: 10
B – Cultivation with sowing of cover aftercrops; pre-sowing tillage for onion in the spring	LJ: 3+2+4+2; W: 6+2+9+2
C – Cultivation with sowing of cover aftercrops and mixing of green biomass with soil; pre-sowing tillage for onion in the spring	LJ: 3+2+4+2+6; W: 6+2+9+2
L J – summer, autumn; W – spring	
1. first ploughing	6. disk ploughing
2. harrowing	7. cultivator tillage
3. medium ploughing	8. rolling
4. sowing of cover crops	9. traditional sowing of onion
5. deep ploughing	10. direct sowing of onion

The control (K) was the traditional tillage method with a mouldboard plough and without the use of cover crops for mulching. The surface area of the plots in a combination was 36 m^2. Mineral fertilization: phosphorus at 66 kg P·ha^{-1} (as triple superphosphate), and potassium at 166 kg K·ha^{-1} (as KCl) were used prior to sowing; nitrogen (as ammonium nitrate) at 75 kg N prior to sowing and 75 kg N·ha^{-1} as topdressing. Onion seeds were sown towards the end of April (23, 22, and 27 April of the successive years) in rows, every 35 cm, at 3.5 kg per ha, using Nibex 500 precision seeder. Herbicides were applied in accordance with the protection schedule for onion to maintain weed-free plots. Spraying against downy mildew with chlorotalonil tetrachloroisophthalonitryl (Gwarant 500 S.C.) at 2.5 kg·ha^{-1} was also carried out every year. The weather conditions during the onion cultivation period are shown in Table 2.

Sprouting of onion plants was assessed in the first week of June, and measurements of the number and height of the leaves were carried out at the peak of vegetative growth, i.e. in the second half of July (15-19th). Harvesting of onion plants was carried out at the beginning of September (2nd-5th). The total yield of onions was determined. After separating bulbous onions, the remaining

crop satisfied the requirements of Class II of marketable yield (WE No. 1508/2001 of 24 July 2001). Two size fractions were isolated from the marketable yield: well-developed (quality) onions, with dia. ≥35 mm, and small onions, with dia. <35 mm). The obtained results were evaluated statistically by means of variance analysis. The significance of the differences was assessed with Tukey's test at P=0.05.

Table 2. Mean monthly air temperatures and amount of precipitation at ES Felin in the years 2004-2006

	Year	Month					
		IV	V	VI	VII	VIII	IX
Temperature (°C)	2004	7.9	11.9	15.8	18.1	18.3	12.8
	2005	9.1	13.2	16.0	19.8	16.9	14.9
	2006	8.7	13.6	16.9	21.9	17.4	15.7
	Mean for 1951-2000	7.5	13.0	16.5	17.9	17.3	12.9
Amount of precipitation (mm)	2004	38.1	38.0	49.9	90.5	48.5	14.2
	2005	18.6	98.0	55.9	109.8	108.7	18.0
	2006	30.3	59.5	37.9	6.8	132.6	11.0
	Mean for 1951-2000	40.6	58.3	65.8	78.0	69.7	52.1

RESULTS AND DISCUSSION

Seed germination

The average number of germinated onion plants over the three years of the experiment was 33.2 per linear metre, with the values ranging from 19.8 to 46.5 (Table 3). The weather conditions during the successive years of the experiment had a significant effect on germination. The highest number of germinated plants was obtained in 2006 (41.6 plants·1 m^{-1}). The spring of 2006, with higher air temperatures and higher soil humidity due to rainfall in May, created favourable conditions for germination (Table 2). The lowest number of onion seeds germinated in the year 2004 (28.9 plants per linear metre), which had the coldest spring with the lowest amount of precipitation. The optimal temperature for the germination of onion seeds is 18°C (Adamicki *et al*. 2005).

In all the years of the experiment, the best germination of onion seeds (an average of 38.3 plants per linear metre) was in the fields cultivated in the traditional way. Lower numbers of germinated plants were obtained under conservation tillage (an average of 32.3 plants per linear metre). In the fields mulched with rye, the number of sprouting plants (35.8 per l m) was higher than in those where vetch was used as the intercrop plant (28.8 per l m). This relationship was recorded in all the combinations with conservation tillage. The method of tilling the soil also had an effect on germination. Onion plants sprouted most numerously in those fields where the biomass of cover plants had been mixed with the soil by pre-winter disk ploughing, with the worst results obtained after disk ploughing in the spring. This trend was recorded for mulching with spring rye as well as for mulching with vetch.

Table 3. Number of germinated plants in the years 2004-2006 depending on the cover crop mulches and the pre-winter and spring tillage methods preceding the sowing

Combination		Number of germinated plants per linear metre			
Cover crop	Soil tillage	2004	2005	2006	Mean
No cover crop	K	37.0	32.3	45.8	38.3
Rye *Secale cereale*	A	35.3	29.5	41.5	35.4
	B	28.3	26.3	44.8	33.1
	C	34.8	35.8	46.5	39.0
	Mean	32.8	30.5	44.3	35.8
Vetch *Vicia sativa*	A	26.5	23.8	37.0	29.1
	B	21.0	26.0	33.5	26.8
	C	19.8	30.0	42.0	30.6
	Mean	22.4	26.6	37.5	28.8
Mean	A	30.9	26.7	39.3	32.3
	B	24.7	26.2	39.2	30.0
	C	27.3	32.9	44.3	34.8
	Mean	27.6	28.6	40.9	32.3
Mean		28.9	29.1	41.6	33.2
$LSD_{0.05}$ for: combinations		16.09	n.s.	n.s.	8.84
years					4.56

Note: K – control: pre-winter ploughing+pre-sowing treatments in spring; A – direct sowing into untilled soil; B – disk ploughing in the spring+pre-sowing spring treatments; C – pre-winter disk ploughing+pre-sowing spring treatments; NS – statistically not significant

Significantly the highest number of germinated plants (39.0 per l m) was found on those plots where rye mulch had been mixed with soil during pre-winter disk ploughing, and the lowest (26.8 plants per l m) where the biomass of vetch had been ploughed into the ground in the spring. The observed relationships can be explained by the differences in soil humidity in the individual experimental combinations, as well as by the differences in the activity of soil microorganisms. Onion seeds are to a large degree affected by pathogens, which significantly inhibits their germination and sprouting of plants. Tylkowska & Dorna (1997) have revealed that onion seeds are commonly infected with *Botrytis allii*. In the microbiological analyses of the soil tested in the experiment, the most colonies of fungi recognized as pathogens were found in the soil mulched with vetch (Pięta & Kęsik 2007). The soil under onion cultivation with spring rye as the cover crop was found to contain the highest number of antagonistic bacteria (*Bacillus* spp., *Pseudomonas* spp.) and fungi (*Gliocladium* spp., *Trichoderma* spp.). The disk ploughing treatment had greatly contributed to an increase in the number of antagonists in the soil. On the other hand, the mulch left on the surface of the ground had little effect on the growth and development of antagonistic microorganisms.

Plant growth

The height of onion plants measured during the peak of vegetative growth ranged from 15.0 to 60.0 cm depending on the year of the experiment. In the middle of July, plants were on average 36.4 cm high and had produced 5.2 leaves (Table 4). The best growth of onion plants was in 2004, and the worst in 2006. The severe drought and heatwaves in the summer of 2006 (Table 2) significantly arrested the growth of plants. After germination and during the intensive period of leaf growth, the most favourable for onion plants is a temperature in the range of 12-15°C (Adamicki *et al*. 2005).

Table 4. Effect of cover plants and the method of pre-winter and spring tillage preceding the sowing on onion growth characteristics during the peak of vegetative growth in the years 2004-2006

Combination		Height in cm				Number of leaves per plant			
Cover crop	Soil tillage	2004	2005	2006	Mean	2004	2005	2006	Mean
No cover crop	K	55.7	39.9	31.6	42.4	7.2	5.2	4.7	5.7
Spring rye *Secale cereale*	A	39.2	36.5	32.8	36.1	6.1	4.9	4.5	5.1
	B	46.6	33.8	36.8	39.1	6.8	4.7	3.9	5.1
	C	39.5	34.1	30.9	34.8	5.8	5.0	3.9	4.9
	Mean	41.7	34.8	33.5	36.7	6.2	4.9	4.1	5.0
Vetch *Vicia sativa*	A	34.3	33.8	32.9	33.6	5.3	4.7	4.8	4.9
	B	40.4	34.3	26.9	33.9	6.5	5.4	4.7	5.5
	C	35.0	36.1	34.6	35.2	6.1	5.5	4.4	5.3
	Mean	36.6	34.7	31.4	34.2	6.0	5.2	4.6	5.3
Mean	A	36.7	35.1	32.8	34.9	5.7	4.8	4.6	5.0
	B	43.5	34.1	31.8	36.5	6.6	5.0	4.3	5.3
	C	37.2	35.1	32.7	35.0	5.9	5.2	4.2	5.1
	Mean	39.2	34.8	32.5	35.5	6.1	5.0	4.4	5.1
Mean		41.5	35.5	32.3	36.4	6.2	5.0	4.4	5.2
$LSD_{0.05}$ for:	combinations	13.8	n.s.	n.s.	7.81	1.5	n.s.	1.03	0.44
	years				4.03				0.33

Note: see Table 3.

The highest and best-leaved (42.4 cm; 5.7 leaves) were the plants growing in the traditionally-cultivated control fields. Conservation tillage reduced the growth of onion plants. Similar results had been obtained by Suzuki *et al*. (2004) while they were determining biometric traits of onion 71 days after sowing. Significantly the shortest were the plants growing in the fields mulched with vetch, and where direct sowing had been carried out (33.6 cm), or where the biomass of vetch had been mixed with the soil by disk ploughing in the spring (33.9 cm). In all the years of the experiment, plants were slightly taller in those fields where spring rye had served as the intercrop, but they produced a

few more leaves after vetch had been used. The soil cultivation method in the combinations of conservation tillage did not have a significant effect on the studied growth characteristics of the onion plant. However, in the years 1997-1999 (Kęsik *et al*. 2001) onion plants were taller after direct sowing into *Phacelia* mulch (57.8 cm) than in traditional cultivation (52.6 cm), and the shortest in no-tillage cultivation without cover crops (49.7 cm), which to a large extent had been decided by weather conditions.

Yield and its structure

The total and marketable yields of onion significantly depended on the weather conditions in the individual years of cultivation (Table 5). The highest yields were obtained in 2005. The total yield from the fields under conservation tillage was then an average of 25.8 t·ha^{-1}, and 36.2 t·ha^{-1} under conventional cultivation, while the marketable yields of onions ≥ 35 mm in diameter were 22.1 t and 31.9 t·ha^{-1}, respectively. The smallest yields of onions, both total and that of large onions, was collected in 2004 despite the fact that the plants in that year were the tallest and produced the most leaves (Table 4).

Table 5. Total yield and the yield of quality onions (≥ 35 mm) in 2004-2006 (t·ha^{-1})

Combination		Total yield (t·ha^{-1})				Yield of onions ≥ 35 mm (t·ha^{-1})			
Cover crop	Soil tillage	2004	2005	2006	Mean	2004	2005	2006	Mean
No cover crop	K	26.0	36.2	21.9	28.0	22.7	31.9	16.0	23.5
Spring rye *Secale cereale*	A	19.1	16.4	22.9	19.4	16.5	12.8	17.0	15.4
	B	20.4	32.2	20.6	24.4	18.5	28.1	14.8	20.5
	C	17.5	27.5	22.6	22.5	14.6	24.1	15.3	18.0
	Mean	19.0	25.4	22.0	22.1	16.5	21.6	15.7	18.0
Vetch *Vicia sativa*	A	13.0	23.8	20.6	19.1	10.1	19.9	13.4	14.5
	B	16.4	25.4	23.6	21.8	11.4	21.6	16.0	16.3
	C	15.6	29.3	23.6	22.8	9.6	26.5	17.6	17.9
	Mean	15.0	26.2	22.6	21.2	10.4	22.7	15.7	16.2
Vetch	A	16.1	20.1	21.7	19.3	13.3	16.3	15.2	14.9
	B	18.4	28.8	22.1	23.1	14.9	24.8	15.4	18.4
	C	16.5	28.4	23.1	22.7	12.1	25.3	16.5	17.9
	Mean	17.0	25.8	22.3	21.7	13.4	22.1	15.7	17.1
Mean		18.3	27.3	22.2	22.6	14.8	23.5	15.7	18.0
$LSD_{0.05}$ for:	combinations				5.18				5.16
	years				2.68				2.66

Note: see Table 3.

Lower temperatures combined with long days in June and July 2004 had slowed down the development of onion bulbs. In contrast, abundant rain in July and August 2005, at higher temperatures (above 16°C), extended the growing

period and favoured the formation and growth of onion bulbs (Doruchowski 1999, Adamicki *et al*. 2005). In 2006, on the other hand, the drought in July hindered the growth of bulbs and reduced the onion yield despite good germination (Table 3).

The different soil cultivation methods had a large effect on onion yields. The most beneficial for onion proved to be traditional tillage with pre-winter ploughing and pre-sowing soil preparations in the spring. The total yield of onions in that case was an average of 28.0 t·ha^{-1}, while the marketable yield of large onions was 23.5 t·ha^{-1}. In those combinations onion plants produced the largest vegetative mass (Table 4), which favoured the production of higher yields (Felczyński 2002).

Conservation methods of soil tillage, as a consequence of using green mulches, markedly reduced onion yields (Table 5). Yet in the experiments by Starkute *et al*. (2006), onion plants in an ecological cultivation utilizing the biomass of intercrop plants yielded better than under traditional cultivation. Also, in an experiment from the years 1997-1999 (Kęsik *et al*. 2001), onion yields were higher after using vetch, *Phacelia* and oat plants as mulch (from 22.9 to 66.3 t·ha^{-1}, depending on the year) than in traditional cultivation (20.0-50.2 t·ha^{-1}). Willumsen & Thorup-Kristensen (2001) did not record decreased yields of onions after using *Vicia villosa, Vicia sativa and Lupinus angustifolius* as intercrop plants. An increase in onion yield in the second year after ploughing under the biomass of field pea and oat as compared with traditional cultivation was recorded also by Jabłońska-Ceglarek *et al*. (2002). On the other hand, in an experiment by Wadas (1998), spring rye used as mulch reduced the size of onion crop. Lower yields of onions under conservation tillage in comparison with conventional methods have also been reported by Rodrigues *et al*. (2006), with their result being dependent on the cultivar. The negative effect of conservation tillage is often associated with biological sorption of nitrogen. However, the nitrogen fertilization in our experiment was sufficient, and chemical analyses did not reveal nitrogen deficiency in the combinations where green mulch had been used (Błażewicz-Woźniak *et al*. 2008).

In the experiment presented here, under conservation tillage, irrespective of the green mulches used, the mixing of the biomass of intercrop plants with the soil by disk ploughing carried out before winter or in spring proved to be beneficial. The worst cultivation system for onion was that of the highest degree of simplification of cultivation represented by the use of direct sowing. The onion yields obtained in that combination were the lowest, the average total yield being 19.3 t·ha^{-1}, with the marketable yield of large onions at 14.9 t·ha^{-1}. Increased onion yields, by 7.3% after mixing the soil with the biomass of a mixture of barley and clover, and by 5.7% after using wheat as mulch, had been reported by Starkute *et al*. (2006).

From the two cover crops used as mulches, spring rye proved to be slightly better for onion. The total onion yield obtained from the plots mulched with spring rye was 22.1 t·ha^{-1}, and the yield of marketable onions ≥ 35 mm in dia. was 18.0 t·ha^{-1}. The yields produced by the plots mulched with vetch were

slightly lower - 21.2 t·ha^{-1} and 16.2 t·ha^{-1}, respectively. Under soil-conserving cultivation, the most favourable combination was the cultivation of onion that made use of spring rye as mulch and in which the ploughing-under of the plant biomass was carried out in the spring. In this combination, the highest total yield of onions was produced, which was an average of 24.4 t·ha^{-1}, with the marketable yield of quality onions at 20.5 t·ha^{-1}. On the basis of the microbiological analysis of the soil in this combination of conservation tillage, the composition of soil microorganisms was found to be the most favourable (Pięta & Kęsik 2007). Also, the water supply determined at the peak of vegetative growth was the highest in these combinations of the experiment, which was favourable to the production of good yields (Kęsik *et al*. 2007). The growing of onion based on direct sowing into the ground mulched with vetch turned out to be disadvantageous. In this combination, the yields obtained were the lowest.

Weather conditions were also found to have played a significant role in determining the yield of small marketable onions (< 35 mm) (Table 6). The highest yield of such onions was obtained in 2006 (an average of 4.3 t·ha^{-1}), and the lowest in 2004 (an average of 0.8 t·ha^{-1}). In 2006, the planting density was the highest thanks to extensive germination; however, the drought in July had arrested the growth of onion bulbs, which resulted in a large crop of smaller onions (< 35 mm). Under traditional cultivation, the yield of small onions was slightly higher (3.1 t·ha^{-1}) than for the cultivation with green mulches (2.3 t·ha^{-1}). This could be associated with higher humidity levels in the mulched soil, especially in the initial period of plant growth, which favoured the development of larger bulbs (Kęsik *et al*. 2006, 2007). Under conservation tillage involving the use of sorghum, Suzuki *et al*. (2004) had obtained onions with a larger diameter and unit mass than those grown in a traditional way. The smallest crop of small onions was collected from the plots on which vetch as mulch had been mixed with the soil before winter.

The factors studied in the experiment also affected the yield of bulbous onions (Table 6). Onion plants cv. Wolska produced on average 2.1 t per ha of onions with leaves that were still fresh. It was found that the introduction of mulching plants had caused an increase in the yield of onions of this class, from 1.4 t·ha^{-1} in traditional cultivation to 2.3 t·ha^{-1} in the cultivation with plant mulches. It was also shown that vetch used as mulch had a favourable effect on the formation of bulbous onions (2.8 t·ha^{-1}) in comparison with the mulch of spring rye (1.7 t·ha^{-1}). In the studies by Jabłońska-Ceglarek *et al*. (2006), the ploughing-under of the biomass of vetch had resulted in producing the most favourable effect on the weight and length of the white part of the leek.

The largest amounts of bulbous onions were collected from the plots where vetch as mulch had been ploughed under in the spring (an average of 3.3 t·ha^{-1}), and the least from the plots cultivated traditionally (1.4 t·ha^{-1}). Mulch from vetch used under conservation tillage, mixed with the soil during disk ploughing in the spring, was therefore the least beneficial because of its effect on increasing the yield of bulbous onions. In the assessment of the other combinations of conservation tillage, the most beneficial in this respect proved to be the method

of cultivating onion in the field mulched with spring rye and disk-ploughed in the spring, the result of which was the smallest crop of bulbous onions (an average of 1.5 t·ha^{-1}).

Table 6. Yield of small and bulbous onions cv. Wolska in the years 2004-2006 (t·ha^{-1})

Combination		Small onions < 35 mm (t·ha^{-1})				Bulbous onions (t·ha^{-1})			
Cover crop	Soil tillage	2004	2005	2006	Mean	2004	2005	2006	Mean
No cover crop	K	2.7	2.8	3.9	3.1	0.6	1.5	2.1	1.4
Spring rye *Secale cereale*	A	0.8	1.6	4.5	2.3	1.8	2.0	1.4	1.7
	B	0.4	2.5	4.4	2.4	1.5	1.6	1.4	1.5
	C	0.5	2.4	5.4	2.8	2.4	1.0	1.9	1.8
	Mean	0.6	2.2	4.7	2.5	1.9	1.5	1.6	1.7
Vetch *Vicia sativa*	A	0.7	2.4	3.6	2.2	2.2	1.6	3.6	2.4
	B	0.3	2.2	3.9	2.2	4.7	1.5	3.6	3.3
	C	0.1	1.8	4.4	2.1	5.8	1.1	1.6	2.8
	Mean	0.4	2.1	4.0	2.2	4.2	1.4	2.9	2.8
Mean	A	0.8	2.0	4.0	2.3	1.9	1.8	2.5	2.1
	B	0.4	2.4	4.1	2.3	3.1	1. 6	2.5	2.4
	C	0.3	2.1	4.9	2.4	4.1	1.0	1.8	2.3
	Mean	0.5	2.1	4.3	2.3	3.0	1.5	2.3	2.3
Mean		0.8	2.3	4.3	2.4	2.7	1.5	2.2	2.1
$LSD_{0.05}$ for: combinations					0.97				1.24
years					0.50				0.64

Note: see Table 3.

The yield structure of onion cv. Wolska, regardless of the experimental factors studied, was in traditional cultivation different from that obtained from the mulched soil. In traditional cultivation, the percentage share of the marketable yield of quality onions ≥ 35 mm in the total yield was 82.7% on average, whereas that of small onions with dia. < 35 mm was 11.9%, and that of bulbous onions only 5.4%. When cultivation involved plant mulches, irrespective of soil tillage methods, the percentage share of marketable onions ≥ 35 mm in the total yield was an average of 77.5%, of small onions 11.1%, and that of bulbous onions as much as 11.4%. The two plant mulches studied did not affect the percentage share of the separate classes of onion in the total yield to the same degree. It was found that spring rye mulch had an advantageous effect on increasing the percentage share of the marketable yield of large onions in the total yield, which was on average 81.3%, whereas after mulching with vetch this share was only 75.0%. What was also characteristic in this combination was the increase in the percentage share of bulbous onions from 7.7% for the rye mulch to 15.6% when mulched with vetch. Comparing the different cultivation meth-

ods, the most beneficial effect on onion yield structure was produced by disk ploughing in the spring the field mulched with spring rye, for which the average share of the marketable yield of large onions was 83.3%, with the lowest share (74.2%) recorded for the same soil tillage method but employing vetch for mulching.

CONCLUSIONS

1. Spring rye as a cover crop had a more beneficial effect on onion seed germination than vetch. Onion plants came up best in the fields where spring rye mulch had been mixed with the soil by pre-winter disk ploughing. Mixing the biomass of vetch by disk ploughing in the spring reduced the extent of sprouting of onion plants.
2. Onion plants grew best following traditional tillage. In those fields, the plants were the tallest and produced the most leaves. Conservation tillage reduced the vegetative growth of onion plants. After using spring rye, the plants were somewhat taller, but produced fewer leaves than after mulching with vetch.
3. The soil-conserving factor introduced to onion cultivation by employing the mulching effect of intercrop plants of spring rye and vetch reduced the size of both the total yield and marketable yield of onions in comparison with traditional cultivation.
4. The most beneficial pre-sowing tillage method for onion was the traditional tillage method involving pre-winter ploughing and soil preparation treatments in the spring, without the use of any mulching plants.
5. Of the two soil-mulching plant species under comparison, a more favourable effect on onion yield was produced by spring rye.
6. As for conservation tillage, the best results were produced after mixing the soil with rye mulch by disk ploughing in the spring. This combination made it possible to obtain the highest total yield and marketable yield of onions, and also the highest percentage share of marketable yield in total yield.
7. Weather conditions were found to have a significant effect on onion growth and yield.

REFERENCES

Adamicki F., Dobrzański A., Felczyński K., Robak J., Szwejda J. 2005. Metodyka integrowanej produkcji cebuli. PIORIN Warszawa 38 pp. [in Polish]

Błażewicz-Woźniak M., Kęsik T., Wach D., Konopiński M. 2008. The influence of conservation tillage on the mineral elements content in soil and chemical composition of onion. Acta Sci. Pol., Hortorum Cultus 7(2): 61-72.

Doruchowski R.W. 1999. Charakterystyka botaniczna, biologia wzrostu i rozwoju. In: „Cebula. Technologia uprawy i przechowywania". Praca zbiorowa. Instytut Warzywnictwa Skierniewice: 14-30. [in Polish]

Felczyński K. 2002. Sposoby uprawy cebuli w Polsce i ich aktualne znaczenie w praktyce. VII Ogólnop. Konf. Nauk. "Uprawa, ochrona i przechowywanie warzyw cebulowych" Skierniewice, 7 listopada 2002: 11-18. [in Polish]

Gruszecki R., Tendaj M. 2001. Effect of cultivation method on the earliness and structure of onion yield. Veget. Crops Res. Bull. 54 (2): 43-48.

Höppner F., Zach M., Sommer C. 1995. Conservation tillage – a contribution to soil protection – effects on plant yields. Konf. Nauk. „Siew bezpośredni w teorii i praktyce" Szczecin-Barzkowice: 151-158.

Jabłońska-Ceglarek R., Rosa R., Zaniewicz-Bajkowska A., Franczuk J., Kosterna E. 2006. [Successive effect of green manures in the form of forecrop in leek cultivation]. Acta Agrophysica 7(3): 577-589. [in Polish with English summary]

Jabłońska-Ceglarek R., Rosa R., Zaniewicz-Bajkowska A., Franczuk J. 2002. Successive effect of green manures in form of forecrops in cultivation of onion. Folia Hort. 14/1: 3-12.

Kęsik T. 2002. Energooszczędne systemy uprawy. Roczn. AR Pozn. CCCXLI, Ogrodn. 35: 193-197. [in Polish]

Kęsik T., Błażewicz-Woźniak M., Konopiński M., Wach D., Mitura R. 2007. [The effect of cover crop mulches and reduced soil tillage in onion cultivation on some features of soil]. Roczn. AR Poznań, Ogrodnictwo 41: 517-522. [in Polish with English summary]

Kęsik T., Konopiński M., Błażewicz-Woźniak M. 2001. [Response of onion and carrot on soil mulching and no-tillage cultivation system]. Acta Agrophysica 45: 95-104. [in Polish with English summary]

Kęsik T., Konopiński M., Błażewicz-Woźniak M. 2006. [Effect of pre-winter soil tillage and cover crop mulches on water retention, compaction and differential porosity of soil after winter time]. Acta Agrophysica, 7(4): 915-926. [in Polish with English summary]

Kuś J. 1995. Systemy gospodarowania w rolnictwie. Rolnictwo integrowane. Wyd. IUNG Puławy: pp. 38. [in Polish]

Nyakatawa E.Z., Reddy K.C., Lemunyon J.L. 2001. Predicting soil erosion in conservation tillage cotton production systems using the revised universal soil loss equation. Soil and Tillage Research 57, 4: 213-224.

Parker M.A., Nyakatawa E.Z., Reddy K.C., Reeves D.W., Santen E. 2002. Soil carbon and nitrogen as influenced by tillage and poultry litter inn North Alabama. Making conservation tillage conventional: building a future on 25 years of research. Preec. of 25th: Auburn USA: 283-287.

Pięta D., Kęsik T. 2007. The effect of conservation tillage on microorganism communities in the soil under onion cultivation. Electronic Journal of Polish Agricultural Universities, 2007, vol. 10, Issue 1. Topic Horticulture.
http:/www.ejpau.media.pl/volume10/issue1/art-21.html

Rasmussen K.J. 1999. Impact of ploughless soil tillage on yield and soil quality: A Scandinavian review. Soil Till. Research 53: 3-14.

Rodrigues G.B., Nakada P.G., Silva D.J.H.da., Dantas G.G., Santos R.R.H. 2006. Performance of onion cultivars grown in the organic and conventional systems in Minas Gerais State, Brazil. Hortic. Brasil. 24(2): 206-209.

Rumpel J. 2003. Uprawa cebuli. Hortpress Sp. z o.o: 74-78. [in Polish]

Shrestha A., Lanini T., Wright S., Vargas R., Mitchell J. 2006. Conservation tillage and weed management. ANR Publication 8200. Univ. California. ISBN-13: 978-1-60107-392-1, 14 pp.

Starkute R., Duchovskiene L., Zalatorius V. 2006. Agrobiological evaluation of plants for green manure and its influence on yield. Sodininkyste Darzinin 25(4): 261-269.

Suzuki T., Adachi K., Kabayashi T. 2004. Growth and yield of onion by conservation tillage cultivation under preceding sorghum cropping and fallow conditions in relation to arbuscular mycorrhizal infection. Precc. of Intern. Symp. NARO KONARC Okinawa 2004, http://www.knaes.affre.go.jp/indexe.html.

Teasdale J.R., Mohler C.L. 2000. The quantitative relationship between weed emergence and the physical properties of mulches. Weed Sci. 48, 3: 385-392.

Tylkowska K., Dorna H. 1997. Zależność między stopniem zakażenia nasion cebuli przez *Botrytis allii* a ich kiełkowaniem i porażeniem roślin przez tego patogena. Mat. VII Ogólnop. Zjazdu Hodowców Rośl. Ogrodn. „Hodowla nasiennictwo i szkółkarstwo roślin ogrodniczych o podwyższonej jakości" Szczecin, 11-13 września 1997: 359-363. [in Polish]

Wadas W. 1998. Productive effect of different forms of organic fertilizer applied in vegetable cultivation. Roczn. Nauk Roln. Seria A, 113(1/2): 201-211.

Willumsen J., Thorup-Kristensen K. 2001. Effects of green manure crops on soil mineral nitrogen available for organic production of onion and white cabbage in two contrasting years. Biol. Agric. Hortic. 18(4): 365-384.

Zimny L. 1999. [Conservation tillage]. Post. Nauk Roln. 5/99: 41-51. [in Polish with English summary]

WZROST I PLONOWANIE CEBULI W WARUNKACH UPRAWY KONSERWUJĄCEJ

Streszczenie

W doświadczeniu polowym z uprawą konserwującą badano wpływ zastosowania roślin okrywowych: żyta jarego (*Secale cereale*) i wyki siewnej (*Vicia sativa)* oraz zróżnicowanych sposobów uprawy przedsiewnej: uprawa zerowa (*no-tillage*), talerzowanie wiosną, talerzowanie przed zimą w porównaniu z uprawą konwencjonalną, na wzrost i plonowanie cebuli odm. Wolska.

Cebula wschodziła najlepiej na obiektach, gdzie mulcz z żyta jarego wymieszano z glebą talerzowaniem przedzimowym. Wymieszanie z glebą biomasy wyki siewnej talerzowaniem wiosennym ograniczyło wschody cebuli. Wzrost cebuli był najlepszy po uprawie tradycyjnej. Na tych obiektach rośliny były najwyższe i wytworzyły najwięcej liści. Zastosowany w uprawie czynnik konserwujący glebę poprzez wykorzystanie mulczującego działania roślin międzyplonowych żyta jarego i wyki siewnej ograniczył wielkość plonu ogólnego i handlowego cebuli w porównaniu z uprawą tradycyjną. Najkorzystniejszą uprawą przedsiewną pod cebulę była uprawa tradycyjna z orką przedzimową i wiosennymi uprawkami doprawiającymi, bez rośliny mulczującej. Spośród porównywanych roślin mulczujących glebę korzystniejszym wpływem na plonowanie cebuli odznaczało się żyto jare. Biorąc pod uwagę uprawę konserwującą najlepsze efekty dała uprawa wiosenna polegająca na wymieszaniu z glebą mulczu żytniego poprzez talerzowanie.