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THE EFFECT OF COVER PLANTS ON THE YIELD AND CONTENT OF SELECTED COMPONENTS OF CABBAGE VARIETES

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Abstract. Very important element of proecological vegetables cultivation it is cover plants applied. They have favourable influence on the soil environment, indicated the possibility of limiting mineral fertilizer use and also reduce an application of herbicides, allow to keep soil fertility and in this same achieve high and good quality of yield. An experiment was carried out in 2002–2005 at the Experimental Farm in Zawady belonging to University of Podlasie. The objective of the study was the effect of cover plants (phacelia, spring vetch, serradella and oat) ploughed down in the autumn, spring or retained on the soil surface as a cover crop on the yield of red and savoy cabbage, and dry matter and vitamin C contents in white and savoy cabbage was investigated. The effects of covers were compared to the uncovered control. White cabbage cv. 'Masada F_1', red cabbage cv. 'Koda' and savoy cabbage cv. 'Wirosa F_1' were cultivated. Irrespective of the date of ploughing down of cover plants, serradella was the best plant cover preceding red cabbage, and phacelia was most beneficial when preceded savoy cabbage. Oat cover ploughed down in the autumn favoured dry matter accumulation, when spring-incorporated, stimulated vitamin C in white cabbage. The autumn-incorporated phacelia cover resulted in the greatest dry matter and vitamin C contents in savoy cabbage.

Key words: date of ploughing down the cover plant, yield, nutritive value, head cabbage

INTRODUCTION

Catch crops applied to the soil in the form of covers are a significant element of proecological cultivation of vegetables. Its aim is to limit an application of mineral fertilizers and plant protection chemicals as well as preserve permanent soil fertility while maintaining satisfactory yields of high and good quality [Starck 1998].

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The influence of cover plants is reflected in many aspects which include: improved physico-chemical properties of the soil environment, increased biological activity of the soil, it also affects yields [Abdul-Baki et al. 1996, Jabłońska-Ceglarek et al. 2002, Grassbaugh et al. 2004, Kołota and Adamczewska-Sowińska 2004, Cherr et al. 2006] and makes it possible to introduce production simplifications [Songin 1989, Mazur 1999]. There are much less studies on an impact of plants retained in the field as covers on the crop biological value.

The objective of this study was to determine the effect of catch crop plants applied to the soil as covers on the yields and contents of selected nutrients in white, red and Savoy cabbage.

MATERIAL AND METHODS

A field experiment was carried out in 2002–2005 under the conditions of central-eastern Poland on grey brown podzolic soil. Before the experimental set-up, soil pH determined in H_2O was 5.73. The total phosphorus content in soil was 67 $mg \cdot kg^{-1}$ air dry matter (adm), potassium 108 $mg \cdot kg^{-1}$ a.d.m., magnesium 39 $mg \cdot kg^{-1}$ a.d.m., $N\text{-}NO_3$ 10 $mg \cdot kg^{-1}$ a.d.m., $N\text{-}NH_4$ $mg \cdot kg^{-1}$ a.d.m., and calcium 380 $mg \cdot kg^{-1}$ a.d.m. It was set up as a split-block design in three replications. The effect of cover incorporation date: autumn-, spring-incorporated or retained as a cover crop without incorporation till the end of cabbage growth, was investigated. The following plants were selected as covers: phacelia, spring vetch, serradella and oat grown as catch crops. The effects of covers were compared to an uncovered control.

The seeds of plants cover were sown in the 1st decade of August in the years 2002––2004. The seeding rate for cover plants amounted to 15 $kg \cdot ha^{-1}$ for phacelia, 140 $kg \cdot ha^{-1}$ for spring vetch, 60 $kg \cdot ha^{-1}$ for serradella and 240 $kg \cdot ha^{-1}$ for oat. Autumn-incorporated plants cover were ploughed down in late October. Prior to incorporation, plant material samples were collected to determine the yield of fresh and dry matter of covers as well as nitrogen and mineral compound contents. The quantity of fresh and dry matter and macroelements (N, P, K, Ca, Mg) supplied to the soil with the investigated organic manures differed significantly. Among the cover plants the highest fertility value determined the quantity of NPK compounds entered to the soil was characterised biomass of oat, much less serradella [Jabłońska-Ceglarek et al. 2006, Franczuk et al. 2009].

Spring-incorporated covers were worked in mid-May. In the plots where covers were retained, disking was performed in the spring.

In the years 2003-2005, the following species of head cabbage were planted: white cabbage cv. 'Masada F_1', red cabbage cv. 'Koda', and savoy cabbage cv. 'Wirosa F_1'. The cabbages were planted in the first half of June, at the 50 cm × 50 cm row sparing. The mineral fertilizers applied included ammonium nitrate, triple superphosphate, and 60% potassium chloride. A uniform dose of 97 kg N, 90 kg P_2O_5, 146 kg K_2O was applied to all plots before cabbage cultivation. The remaining 60 kg N was top dressed, when cabbage plants started contact by leaves. Chemical protection against diseases and pests was applied according to current Programme of Vegetables Protection. The cabbage harvest was performed manual in the 3rd decade of October. The plot area for

harvest amounted to 16 m^2. During harvest total and marketable yields of cabbage were determined and plant samples for chemical analysis were collected to determine dry matter content by the drying and weighting method and vitamin C content by the Pijanowski method. The total yield of cabbage determined all hades without outer leaves. The marketable yield defined according to PN-72/R-75362 norm. Yielding of white cabbage cv. 'Masada F_1' was showed in the study by Franczuk and Jabłońska-Ceglarek [1998] and Jabłońskiej-Ceglarek et al. [2006]. The changes of dry matter and vitamin C content in red cabbage cultivated after cover plants applied was showed in the study by Franczuk et al. [2009].

The results of the experiment were analysed statistically by means of the analysis of variance. The significance of differences was verified using Tukey test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Yield of cabbage. The average total yields of red cabbage cv. 'Koda' and savoy cabbage cv. 'Wirosa F_1' amounted to, respectively, 45.76 $t \cdot ha^{-1}$ and 42.44 $t \cdot ha^{-1}$. The marketable yield averaged, 41.29 $t \cdot ha^{-1}$ and 39.51 $t \cdot ha^{-1}$, respectively (tab. 1).

Irrespective of the date of incorporation, all investigated species of catch crop covers significantly increased cabbage yields as compared to the cultivation without mulch application. The effects depended on the date of incorporation. A beneficial influence of catch crops on white cabbage yields had been confirmed in earlier studies by Franczuk and Jabłońska-Ceglarek [1998] and Jabłońska-Ceglarek and Franczuk [2002]. Also Abdul-Baki et al. [1996], Hansen and Djurhuus [1997] as well as Kęsik et al. [2000] pointed out to the beneficial influence of cover crops on vegetable yields.

Irrespective of the incorporation date, serradella was the best covers preceding red cabbage and phacelia was the best for savoy cabbage cultivation.

Autumn-incorporated and non-incorporated vetch was similar to well with serradella in terms of red cabbage yield. Autumn-incorporated phacelia and oat significantly reduced red cabbage yields compared with serradella. At the spring date of ploughing down, the remaining kinds of catch crops significantly decreased red cabbage yields as compared to serradella.

The total yield of savoy cabbage following phacelia was significantly higher compared with the remaining kinds of covers, irrespective of the date of their incorporation. Ploughed down in the autumn, oat and vetch covers favoured marketable yields which, however, did not differ significantly from the yields recorded after phacelia. Savoy cabbage after vetch, serradella and oat, either ploughed down in the spring or left on the soil surface produced significantly lower marketable yields as compared to phacelia.

Valuable cover plant was serradella after which was achieved high yield of white and red cabbage. Winiarska and Kołota [2004], estimated the yielding effect of leaving mulches in the leek cultivation was found that serradella despite of low biomass yield and entered mineral compounds gave batter yielding effect compared with winter rape. Sadowski [1992] and Wadas [1997] reported high productivity of phacelia catch crop in the cultivation of vegetables. Earlier studies by Franczuk [2006] and Wadas [1998]

Table 1. Yield of head cabbage varietes
Tabela 1. Plonowanie odmian kapusty głowiastej

Cultivar Odmiana	Kind of plants cover Rodzaj okrywy roślinnej	Date of ploughing down of mulch – Termin przyorania mulczu							
		A*	B*	C*	Mean Średnio	A*	B*	C*	Mean Średnio
		Total yield – Plon ogółem, t ha^{-1}				Marketable yield – Plon handlowy, t ha^{-1}			
Red cabbage cv. 'Koda' Kapusta głowiasta czerwona 'Koda'	control – kontrola	41.51	36.29	38.68	38.83	37.01	32.85	34.22	34.69
	phacelia – facelia	50.06	45.63	45.54	47.08	46.02	39.94	41.25	42.41
	vetch – wyka	53.42	44.89	46.99	48.43	48.74	40.55	42.63	43.97
	serradella – seradela	54.02	49.14	48.69	50.62	49.53	44.32	43.90	45.92
	oat – owies	48.44	40.01	43.14	43.86	44.42	35.72	38.30	39.48
	mean – średnio	49.49	43.19	44.61	45.76	45.14	38.68	40.06	41.29
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Date of ploughing down – Termin przyorania					1.72				1.66
Kind of cover – Rodzaj okrywy					2.67				2.51
Date of ploughing down × Kind of cover – Termin przyorania × Rodzaj okrywy					2.30				2.11
Savoy cabbage cv. 'Wirosa F_1' Kapusta włoska 'Wirosa F_1'	control – kontrola	33.03	37.05	33.69	34.59	30.14	33.98	31.48	31.87
	phacelia – facelia	48.62	49.65	47.74	48.67	45.57	46.53	44.84	45.65
	vetch – wyka	45.18	41.46	39.67	42.10	43.43	37.85	36.67	39.32
	serradella – seradela	43.84	40.15	42.13	42.04	41.30	36.73	39.19	39.07
	oat – owies	48.58	42.66	43.20	44.81	45.85	39.19	39.91	41.65
	mean – średnio	43.85	42.19	41.29	42.44	41.26	38.85	38.42	39.51
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Date of ploughing down – Termin przyorania					1.53				1.88
Kind of cover – Rodzaj okrywy					3.89				3.67
Date of ploughing down × Kind of cover – Termin przyorania × Rodzaj okrywy					2.57				3.50

A* – ploughing down in the autumn – przyorany jesienią,
B* – ploughing down in the spring – przyorany wiosną,
C* – leaving without ploughing down – pozostawiony bez przyorania

Table 2. Nutritive value of head cabbage varietes
Tabela 2. Wartość odżywcza odmian kapusty głowiastej

Cultivar Odmiana	Kind of plants cover Rodzaj okrywy roślinnej	Date of ploughing down of mulch – Termin przyorania mulczu							
		A*	B*	C*	Mean Średnio	A*	B*	C*	Mean Średnio
		Dry matter – Sucha masa [%]				Vitamin C – Witamina C [mg%]			
White cabbage cv. 'Masada F_1' Kapusta głowiasta biała 'Masada F_1'	control – kontrola	9.30	9.01	9.04	9.12	20.56	21.20	21.62	21.12
	phacelia – facelia	9.17	8.96	8.52	8.88	21.09	20.76	20.72	20.86
	vetch – wyka	8.65	8.48	8.97	8.70	20.96	20.98	21.50	21.15
	serradella – seradela	8.68	9.15	9.37	9.07	20.42	22.00	21.54	21.32
	oat – owies	9.59	9.33	8.33	9.25	21.81	22.41	21.88	22.03
	mean – średnio	9.08	8.99	8.95	9.00	20.97	21.47	21.45	21.30
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Date of ploughing down – Termin przyorania					n.s.– n.i.				0.46
Kind of cover – Rodzaj okrywy					0.24				0.59
Date of ploughing down × Kind of cover – Termin przyorania × Rodzaj okrywy					0.58				0.70
Savoy czbbage cv. 'Wirosa F_1' Kapusta włoska 'Wirosa F_1'	control – kontrola	12.74	14.16	13.12	13.34	28.69	29.64	29.32	29.22
	phacelia – facelia	14.77	13.62	14.42	14.27	32.10	28.84	31.66	30.87
	vetch – wyka	13.04	13.04	14.69	13.59	29.55	28.80	30.33	29.56
	serradella – seradela	13.72	13.53	14.56	13.94	30.54	29.78	30.32	30.21
	oat – owies	14.05	14.17	13.02	13.75	30.49	30.37	31.52	30.79
	mean – średnio	13.67	13.70	13.96	13.78	30.27	29.49	30.63	30.13
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Date of ploughing down – Termin przyorania					n.s. – n.i.				0.49
Kind of cover – Rodzaj okrywy					0.56				0.69
Date of ploughing down × Kind of cover – Termin przyorania × Rodzaj okrywy					0.62				0.81

A* – ploughing down in the autumn – przyorany jesienią,
B* – ploughing down in the spring – przyorany wiosną,
C* – leaving without ploughing down – pozostawiony bez przyorania.

stressed the positive effect, in terms of white cabbage yield, of respectively, spring-incorporated and autumn-incorporated vetch.

Dry matter and vitamin C contents. Average dry matter contents of white and savoy cabbages amounted to 9.00 and 13.78%, white the vitamin C contents 21.30 and 30.13 mg%, respectively (tab. 2).

Dry matter and vitamin C content in white and savoy cabbage significantly depended on the kind of cover and the date of ploughing down.

Dry matter accumulation in white cabbage was favoured by oat an serradella when the vegetable followed the autumn- or spring-incorporated cereal, and the non-incorporated serradella. Autumn-incorporated vetch and serradella, spring-incorporated vetch and phacelia and oat left without ploughing down significantly decreased dry matter content. Most vitamin C was in the white cabbage following oat, irrespective of the date of ploughing down. The remaining catch crops, when ploughed down in autumn, spring-incorporated vetch and phacelia and no covering applied at these dates significantly decreased vitamin C content in white cabbage as compared to oat cover. The most of vitamin C contained white cabbage cultivated after oat catch crops irrespective of the date of ploughing down plants cover.

Savoy cabbage cultivated after autumn-incorporated phacelia contained the significantly greatest quantities of examined components. Spring-incorporated oat favoured their accumulation, too. In the spring date similar to achieved after oat dry matter content was obtained in the savoy cabbage cultivated in the control object without covering and vitamin C after serradella catch crop and in control without covering. The cabbage cultivated after vetch left without ploughing down contained most dry matter and the plants grown after phacelia catch crop had most vitamin C. Leaving without ploughing down cover with oat significantly decrease dry matter content and with vetch and serradella vitamin C content. Significant decreases in the contents of these compounds were detected in savoy cabbage cultivated without covering.

The quality of yield which, according to Doruchowski [1997], is conditioned by the amounts of vitamins, minerals and protein contained in it, is a genetically-conditioned characteristic. However, the influence of cultural factors, e.g. soil covering, is important, too [Kołota and Adamczewska-Sowińska 2004, Olfati et al. 2008]. Jabłońska-Ceglarek et al. [1994a, 1994b] stressed the beneficial influence of autumn-incorporated catch crops on the nutritive value of white cabbage. Jabłońska-Ceglarek and Rosa [2003] applied spring-incorporated green manures ploughed down recorded increased vitamin C contents in red beet.

CONCLUSION

1. Irrespective of the date of ploughing down of cover plants, serradella was the best plant cover preceding red cabbage, and phacelia was most beneficial when preceded savoy cabbage.

2. Oat cover ploughed down in the autumn favoured dry matter accumulation, when spring-incorporated, stimulated vitamin C in white cabbage.

3. Savoy cabbage following autumn-incorporated phacelia had the highest dry matter and vitamin C contents.

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WPŁYW ROŚLIN OKRYWOWYCH NA PLONOWANIE I ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW W ODMIANACH KAPUSTY GŁOWIASTEJ

Streszczenie. Ważnym elementem proekologicznej uprawy warzyw jest stosowanie międzyplonowych roślin okrywowych. Oddziałują one korzystnie na środowisko glebowe, ograniczając zużycie nawozów mineralnych i chemicznych środków ochrony roślin, pozwalają na utrzymanie trwałej żyzności gleby, a jednocześnie uzyskanie wysokiej i dobrej jakości plonów. Badania przeprowadzono w latach 2002–2005 w RSD Zawady należącej do Akademii Podlaskiej. Przedmiotem badań był wpływ roślin okrywowych (facelia, wyka jara, seradela, owies) przyorywanych jesienią, wiosną lub pozostawionych jako okrywa bez przyorania na plonowanie kapusty czerwonej i włoskiej oraz zawartość suchej masy i witaminy C w częściach użytkowych kapusty białej i włoskiej. Efekty ich stosowania porównano z kontrolą bez mulczowania. Uprawiano kapustę głowiastą białą 'Masada F_1', czerwoną 'Koda' i włoską 'Wirosa F_1'. Najlepszym działaniem plonotwórczym, niezależnie od terminu przyorania, w uprawie kapusty czerwonej charakteryzowała się okrywa z seradeli, a w uprawie kapusty włoskiej z facelii. Biomasa owsa przyorana jesienią sprzyjała gromadzeniu suchej masy, a przyorana wiosną – witaminy C w kapuście białej. Okrywa z facelii przyorana jesienią wpłynęła na zwiększenie zawartości suchej masy i witaminy C w kapuście włoskiej.

Słowa kluczowe: termin przyorania roślin okrywowych, plon, wartość odżywcza, kapusta głowiasta

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