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Effect of living mulches on white head cabbage (*Brassica oleracea* var. *capitata subvar. alba* L.) yielding

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ABSTRACT

The effect of meadow fescue, common vetch, and white clover, used as living mulches, on white cabbage yielding, soil aggregates water resistance, and weed infestation was investigated in Garlica Murowana near Kraków in 1998 and 2000. After the living mulches were broad-seeded, transplants of white cabbage 'Lennox F_1' were planted (at the beginning of May) into mulch, with spacing of 70 × 50 cm. During the two years all the used mulches decreased the total and marketable yield of cabbage in comparison with the control. The beneficial effect of living mulches on aggregates water resistance was found. The number of aggregates of 2.50-1.00 mm in diameter increased in mulched soils in both years, whereas the number of the smallest ones (0.25 mm) - decreased. The pronounced effect of living mulches on the reduction of weed infestation was found in the two years of the investigation.

INTRODUCTION

The birth of the conventional production system, which is dominant to a present day, coincided with the development of farm machinery and agrochemical revolution, i.e. nitrogen fertilizers and pesticides, which quickly became its basis. Utilization of plastics for mulches and drip irrigation was also developed shortly thereafter. Unfortunately the uses of these components contribute to the contamination of the environment (Abdul-Baki et al. 1996, Bottenberg et al. 1997, Abdul-Baki et al. 2002). Alternative production system (often referred to as the sustainable system) falls in between conventional and the organic systems and promotes crop production which relies upon crop rotations, crop residues, animal manures, off-farm organic wastes, proper cultivation, mineral-bearing rocks, and aspects of biological pest control. Cover crops and living mulches are essential components of sustainable agriculture (Phatak 1992). Living mulches can be sowed in the autumn or spring and are allowed to grow after the main crop has been planted, whereas cover crops are previously killed.

Living mulches limit the negative effects of soil cultivation and increase the stability of natural environment. They loosen the soil, restrain the leaching of mineral compounds deep into the soil profile, and prevent the degradation of humus compounds. Owing to a protective layer produced by these mulches the development of weeds is restrained and the water resistance of soil aggregates is improved (Mangan et al. 1995). However, living mulches compete for light, water, and nutrients with cultivated plants, contribute to decreases in the humidity and temperature of soil in spring (Sarrantonio 1992). Vegetable crop growth and yield are affected by living mulch system in varying ways, depending on species chosen for a mulch, main crop species, and environmental conditions, etc.

The aim of the present investigation was to determine the effect of meadow fescue, white clover, and common vetch used as living mulches on white cabbage yielding, soil aggregates water resistance, and weed infestation.

MATERIAL AND METHODS

The investigation was conducted in 1998 and 2000 in Garlica Murowana near Kraków on brown soil developed on loess (pH_{KCl} 4.8, organic C level 2.2%). The combinations of the experiment included three mulch treatments (clover, vetch, and fescue), which were compared to two bare soil controls: weeded and non-weeded. The living mulches were broad-seeded on the 15th of April, at a rate of 18 kg ha^{-1} white clover (*Trifolium repens* L.), 50 kg ha^{-1} common vetch (*Vicia sativa* L.), and 28 kg ha^{-1} meadow fescue (*Festuca pratensis* Huds.). Transplants of white cabbage 'Lennox F_1' were planted 5.05.1998 and 11.05.2000 into living

mulch, with spacing of 70 × 50 cm. The experiment was established in a randomised block design in four replications on 12.25 m^2 plots (3.5 x 3.5 m) with 35 cabbage plants per plot. The nutrients were supplied at the level of 230 kg N, 80 kg P_2O_5, and 300 kg K_2O per ha. Mowing was executed when mulch started to over-top cabbage. During the vegetation period in 1998 the mulches were mown 3 times: 5.06, 17.06, and 18.08, in 2000 – 4 times: 23.05, 20.06, 4.07, and 21.08. The cut biomass was left on the plots. The weeds in non-weeded control were treated like mulch: mown and left on plot. The infestation of the plots was evaluated twice each year (1^{st} measurement 5^{th} on June and 2^{nd} one on 15^{th} July). The number and fresh weight of weeds from 1 m^2 was determined. During harvest conducted, in mid-October the total and marketable yield was assessed. The marketable yield consisted of healthy cabbage heads with no insects damages, not cracked and not overgrowth.

The water resistance of aggregates by using the method of wet sieving according to Kulleman was assessed in the soil before and after the growing season.

The results were statistically verified by using analysis of variance, the significant differences were evaluated using the Student t test at $p = 0.05$.

RESULTS AND DISCUSSION

The living mulches affected a decrease in the yield of cabbage (Table 1). In 1998 a total yield decrease varied from 24.5% with the clover mulch to 34.1% with vetch in comparison with the regularly weeded plots and was at the level of that from non-weeded treatments. In 2000 no significant differences occurred between the mulched plots and these with the non-weeded cabbage. Yield decreases varying from 38.2% in the plots with meadow fescue to 44.3% in the treatment with vetch in comparison with the weeded control. In 1998 the marketable yield varied from 46.41 t ha^{-1} to 63.25 t ha^{-1}, and no significant differences were observed between objects. In 2000 living mulches decreased cabbage marketable yield, which remained at the level of that from non-weeded control. The investigations of the effect of living mulches on the height and quality of yield of different vegetable species gave discrepant results. Some authors (Schonbeck et al. 1993, Bottenberg et al. 1997, Masiunas et al. 1997) observed negative effects of cover crops or living mulches on the height and quality of yields of cabbage. According to Bottenberg at al. (1997) lower yields in treatment with cereal rye residue mixed with red clover living mulch were probably due to competition between the living mulch and the cabbage. They suggest that difference in soil temperatures was not great enough to explain the treatment effects on yield. In experiments carried out by Adamczewska-Sowińska and Kołota (2002) the yields

of tomato grown in living mulches of darnel and clover was reduced by 5.7% on the average in comparison with a non-mulched combination, the species sown-in for mulching significantly affecting the yield. Authors suggest that the differences in response of various species probably depend on varied moisture conditions and hence the competition for water and nutrients. For this reason the proper selection of plant species for living mulch is so important. In the present experiment the lowest total and marketable yield and the lowest mean weight of cabbage head were found in the treatments mulched with vetch. This finding is in agreement with the results reported by Masiunas et al. (1997), who observed higher decrease in cabbage yielding, when planted in hairy vetch cover crop in comparison with cereal rye cover crop and perennial ryegrass living mulch. Contrary to the last authors Schonbeck et al. (1993) obtained higher yields of cabbage grown with vetch cover crop than in rye one.

Table 1. Effect of living mulches on white head cabbage yielding (t ha^{-1})

Treatments	1998	2000	Mean
		Total yield	
Weeded control	73.22 b*	103.53 b	88.37 b
Non-weeded control	57.29 ab	63.71 a	60.50 a
White clover	55.29 ab	59.07 a	57.18 a
Meadow fescue	52.55 a	64.02 a	58.28 a
Common vetch	48.25 a	57.69 a	52.97 a
		Marketable yield	
Weeded control	63.25	75.11 b	69.18 b
Non-weeded control	54.10	47.05 a	50.57 a
White clover	51.55	40.38 a	45.96 a
Meadow fescue	47.47	34.77 a	41.12 a
Common vetch	46.41	36.87 a	41.64 a

*Values followed by the same letter within columns are not significantly different according to the least significant difference test at $p \leq 0.05$

The advantage of using the living mulches is their beneficial effect on soil properties owing to their protective and structure-forming capabilities. Legumes species, because of a robust, deep root system, are the most effective ones in soil structure improvement (Debruck 1997). Living mulches create ideal conditions to create new and to prevent already existing aggregates structure. Moreover, they produce considerable amounts of biomass, which cover the surface protecting the soil from erosion (Hargrove 1986). The beneficial effect of living mulches on water resistance was shown in Table 2.

Table 2. Effect of living mulches on the content of water resistance soil aggregates (%) in 1998 and 2000

Treatments		Soil aggregates in diameter (mm)								
		1998			2000			Mean		
		2.50-1.00	1.00-0.25	0.25	2.50-1.00	1.00-0.25	0.25	2.50-1.00	1.00-0.25	0.25
Before growing season		52.32 bc*	15.48 bc	18.20 ab	11.60 a	35.25	29.30 b	31.96 ab	25.37 b	23.75
After harvest	Weeded control	28.87 a	18.23 c	25.85 b	27.02 bc	30.05	21.90 ab	27.95 a	24.14 b	23.88
	Non-weeded control	37.68 ab	7.18 ab	18.85 ab	38.91 c	26.30	15.55 a	38.30 bc	16.74 a	17.20
	White clover	59.40 c	8.85 ab	12.10 a	18.03 ab	31.81	24.80 ab	38.72 bc	20.33 ab	18.45
	Meadow fescue	62.38 c	6.40 a	12.13 a	27.37 bc	27.26	23.10 ab	44.88 c	16.83 a	17.62
	Common vetch	57.45 c	7.28 ab	15.37 a	17.07 ab	28.03	27.40 ab	37.26 abc	17.66 a	21.38

* See Table 1

In 1998 the highest percentage of soil aggregates 2.50-1.00 mm in diameter was found in mulched treatments and the lowest one in the weeded control. The numbers of water-resistant aggregates (∅ 2.50-1.00) in mulched soil varied from 57.45% in the mulch of vetch to 62.38% in meadow fescue, and remained at the level equal to the content of aggregates in the soil investigated before the experiment. In mulched treatments the aggregates characterised by the smallest diameter (∅ 0.25 mm) decreased. This beneficial effect shows an improved durability of the lumpy soil structure, i.e. the resistance of aggregates to the devastating effects of the mechanical, physicochemical, and biological type (Roszak 1997). A reverse effect occurred in the weeded control: the number of larger aggregates decreased and that of smaller increased in comparison with their percentage content in the soil before the experiment. The soil without mulching was directly subjected to the destructive effects of rain, solar radiation, wind, and a rapid drop of moisture. In 2000 the percentage of soil aggregates 2.50-1.00 mm in diameter increased in relation to the level before the cabbage production was begun, yet the results were only significant in the treatment mulched with meadow fescue. The greatest increase in the abundance of large aggregates was observed in the control. The mulching affected a decrease in the percentage of the smallest soil aggregates 0.25 mm in diameter but the differences were not statistically verified.

The beneficial effect of living mulches on the reduction of weed infestation was shown in Table 3. Mulches limited the weeding, this effect being most evident in the second term of evaluation when the mulches were strong enough to compete with weeds. In the two years of the experiment the clover mulch limited weed infestation most effectively, the meadow fescue was less effective, while the least effect of common vetch was observed.

Table 3. Effect of living mulches on weed infestation in cabbage

Treatmants	1998		2000		Mean	
	5th June	15th July	5th June	15th July	5th June	15th July
	fresh weight of weeds (kg m^{-2})					
Non-weeded control	1.34 b*	4,89 c	0.66 b	2.83 c	1.00 b	3.86 c
White clover	0.27 a	0.00 a	0.15 a	0.29 a	0.21 a	0.15 a
Meadow fescue	1.00 ab	2.27 ab	0.27 a	0.35 a	0.64 ab	1.31 ab
Common vetch	0.66 a	2.83 bc	0.16 a	2.00 b	0.41 a	2.42 bc
	number of weeds per m^2					
Non-weeded control	345.50 b	88.00 c	142.67 b	101.33 c	244.09 b	94.67 c
White clover	138.00 a	0.75 a	62.67 a	20.00 a	100.34 a	10.38 a
Meadow fescue	251.50 ab	60.25 b	70.67 ab	57.33 b	161.09 a	58.79 b
Common vetch	214.00 ab	61.50 bc	73.33 ab	72.00 bc	143.67 a	66.75 b

* See Table 1

Numerous authors (Lanini et al. 1989, Phatak 1992, Mangan et al. 1995, Masiunas et al. 1997) confirm the beneficial effect of living mulches or cover crops in limiting the weed infestation. Infante and Morse (1996) compared the effects of a herbicide and living mulches (white and red clover, and vetch) and did not find differences in the infestation level. Abdin et al. (2000) also found that the cover crop mulches and the chemical weeding equally efficiently protected plots against weed infestation.

CONCLUSIONS

1. The living mulches decreased cabbage yielding in comparison with regularly weeded control.
2. The advantage of using the living mulches is their beneficial effect on water-resistance of aggregates. The number of soil aggregates 2.50-1.00 mm in diameter increased in mulched soils both years.
3. The beneficial effect of living mulches on the reduction of weed infestation in cabbage was determined.

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WPŁYW ŻYWYCH ŚCIÓŁEK NA PLONOWANIE KAPUSTY GŁOWIASTEJ BIAŁEJ

Streszczenie: Celem przeprowadzonych badań było określenie wpływu kostrzewy łąkowej, koniczyny białej i wyki siewnej, zastosowanych jako żywe ściółki, na plonowanie kapusty głowiastej białej oraz na wodoodporność agregatów glebowych i zachwaszczenie. Badania prowadzono w Garlicy Murowanej koło Krakowa w roku 1998 i 2000. Żywe ściółki wysiewano rzutowo, a w nie wysadzano kapustę odmiany Lennox F_1 (na początku maja) w rozstawie 70 × 50 cm. W obu latach uprawy żywe ściółki wpłynęły na obniżenie plonu ogólnego i handlowego kapusty w porównaniu z kontrolą bez stosowania ściółki, regularnie odchwaszczaną. Istotną zaletą stosowania żywych ściółek był ich korzystny wpływ na wodoodporność agregatów glebowych. W obu latach wykazano korzystny wpływ żywych ściółek na wzrost zawartości wodoodpornych agregatów o największej średnicy (2,50-1,00 mm), a spadek zawartości agregatów najmniejszych (0,25 mm). Stwierdzono korzystny wpływ ściółek na ograniczenie zachwaszczenia.

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