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THE EFFECT OF LIVING MULCHES ON YIELD AND QUALITY OF TOMATO FRUITS

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Summary

In the experiment conducted in 2004-2006 there was evaluated the effects of living mulches in tomato (*Lycopersicon esculentum* Mill.) cultivation. As the living mulches there were used white clover (*Trifolium repens* L.), serradella (*Ornithopus sativus* Brot.), perennial ryegrass (*Lolium perenne* L.), and pot marigold (*Calendula officinalis* L.). All these species were sown in the field in early and late April, at the time of tomato planting (20 May) or three weeks thereafter. In some treatments growth rate of living mulches was restricted by mowing or gliphosate application. Tomato plants cv. Delfine F_1 were trained to one stem and tied to stakes. Harvest of fruits was conducted in one week intervals since the end of July till the end of September. In samples of fruits harvested at the end of August there were evaluated the contents of dry matter, vitamin C, total and reducing sugars.

Data of the study showed that serradella and perennial ryegrass were less competitive for tomato than white clover and marigold, due to lower production of biomass at the end of growing period. In the average they reduced the yield of fruits by 21.6%. Irrespective of the plant species used as living mulch, the delay of undersowing to the date of tomato planting or three weeks thereafter as well as restriction of their growth by mowing were the efficient methods for increasing tomato fruit yield. Chemical analysis of tomato fruits did not show any significant influence of compared living mulch species or date of undersowing on contents of dry matter, vitamin C, total and reducing sugars.

key words: tomato, living mulches, sowing term, growth suppression, quality of fruit

INTRODUCTION

Increasing interest in proecological methods of production at the end of XXth century was the response to the degradation of agricultural environment caused by the use of large amounts of pesticides, herbicides, mineral fertilizers

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and machinery for intensive soil tillage. One of its important principles is the conservation tillage, in which at least 30% of plant residues should be left on soil surface during growing the subsequent crop (Leary & De Frank 2000, Erenstein 2002). Currently a great attention in this system of production is being paid for the use of cover crops and living mulches. As the living mulches there are used the plant species that are grown at the same time as vegetable crops during whole or part vegetation period. They protect the surface of the soil against unfavourable factors and improve growing conditions for vegetables (Baumann *et al*. 2000). Species suitable as living mulches should characterize by fast growing in early part of vegetation period, production high yield of biomass, quick soil surface coverage, tolerance to drought and low content of nutrients in the soil (Paine & Harrison 1993). Leary & De Frank (2000) underline that plant species used as the living mulches should be low competitive to cultivated crop and well adapted to local soil and climatic conditions. Annual legumes, grasses and *Brassica* species are mostly recommended for this purpose and used in the practice (Nicholson & Wien 1983, Brandsaeter & Netland 1999, Leary & De Frank 2000, Hooks & Johnson 2003).

Living mulches protect the soil from air and water erosion, destructive effects of mechanical tillage and cause the improvement of soil physical properties. They are also efficient in reduction of nitrates leaching and contamination of surface and ground waters by these compounds. The success of living mulches is the suppression of pests and weeds population (Paschold *et al*. 1995, Siebeneicher 1997). After harvest the biomass of these plants is usually ploughed down like some other green manure. Our previous study with leek showed the reduction of the marketable yield harvested in autumn under influence of living mulches, but they created a favourable conditions for plants left in the field throughout the winter months. White clover used for this purpose caused the increment of participation the spring harvested yield in that obtained in autumn season from 75.1% to 83.4% (Kołota & Adamczewska-Swowińska 2003) due to lower frost damage of plants.

Among vegetables preferred for growing together with living mulches are the following species: tomato, pepper, leek, cole crops, corn and perennial vegetables (Müller-Schärrer & Potter 1991).

MATERIAL AND METHODS

Experiments were conducted in 2004-2006 on field of Vegetable and Ornamental Plants Research Station located near Wroclaw. The effects of living mulches on yield and nutritional value of tomato fruits were evaluated.

As the living mulches there were used the following species: white clover (*Trifolium repens* L.), perennial ryegrass (*Lolium perenne* L.), serradella (*Ornithopus sativus* Brot.) and pot marigold (*Calendula officinalis* L.). Seed of all tested species were sown broadcast in 20 cm wide strips between tomato plant rows in the amount of 5 g per 1 m^2. Sowing dates were outlined on 5th and 27th of April, at tomato transplanting (20 May) and 3 weeks after planting (10 June).

In treatments with first two sowings the growth of living mulches was suppressed by mowing or gliphosate treatment at rate 1440 g·ha^{-1} (Roundup 360 SL 4 L·ha^{-1}) when they covered the soil surface thoroughly. On control plots tomato plants were grown without living mulches. The experiment was established in two factorial design in four replications, with plot area 3 m^2 (2 x 1.5 m).

Transplants of tomato Delfine F_1 cv. were produced in the greenhouse from sowing on 25 March. In the middle of April the seedlings were pricked to the pots with diameter of 10 cm, filled with peat substrate. Well hardened transplants were planted into the field on 20 May in spacing 80 x 50cm.

Phosphorus and potassium fertilization was not required because the amounts of available forms of these nutrients exceeded the standard levels for field tomato equal to 60 mg P and 200 mg K per 1 dm^3 of the soil. Nitrogen was applied at the rate of 150 kg N·ha^{-1} as a preplant dose and 50 N·ha^{-1} as a top dressing in the middle of June.

Plants were trained to a single stem, tied to the wooden stakes 1.5 m high and topped on 1th August. The other operations of plant management were conducted following the commonly accepted recommendations for this species.

Harvest of fully matured fruits lasted since half of July till the end of September was done in one week intervals. Marketable yield contained fruits >3.5 cm in diameter. At the end of August during the time of maximum fruiting, samples of 5 fruits from each plot were collected for evaluation of dry matter, vitamin C, total and reducing sugar contents.

Biomass yield of living mulches was determined at the end of October shortly before ploughing into the soil, upon the base of samples taken from two places in each plot, within the area of 0.5 x 0.2 m. Data of the study were analysed by standard statistical procedure for two factorial design, and the least significant differences calculated by Tukey test at P=0.05.

RESULTS AND DISCUSSION

Results of our study presented as means for three years indicate that kind of plant species, date of sowing as well as method of their growth suppression significantly influenced the biomass yield of living mulches and finally the yield of tomato fruits (Table 1). The highest yield of biomass was produced by pot marigold (32.43 t·ha^{-1}), followed by white clover (20.22 t·ha^{-1}), serradella (15.14 t·ha^{-1}) and perennial ryegrass (12.49 t·ha^{-1}). Differentiation of sowing date from 5th April till 20 of May did not affect the yield of biomass for ploughing. However it was significantly reduced under influence of the delayed sowing term to 10th June, and to similar degree by mowing the plants from early sowings in April. Much more efficient method of plant growth suppression was the application of gliphosate at the rate 1440 g·ha^{-1}. Biomass yield of white clover was reduced in this treatment to 14.09 t·ha^{-1}, while the other tested species to 5.76-6.49 t·ha^{-1}, which was only 31.5% of that provided by the living mulches, with no growth restriction.

Table 1. The yield of biomass of living mulches depending on the plant species, sowing term and of their growth suppression method (in t·ha^{-1}), mean for 2004-2006

Sowing term of living mulch and growth suppression method	Yield of biomass of living mulches				
	Pot marigold	Perennial ryegrass	White clover	Serradella	Mean
05.04.	47.47	17.73	26.31	12.07	25.89
05.04. + c	25.07	11.20	24.04	15.84	19.04
05.04. + h	6.30	6.49	14.09	5.76	8.16
27.04.	42.67	14.80	27.20	14.47	24.78
27.04. + c	24.84	12.36	22.40	13.66	18.31
20.05.	50.53	14.93	20.71	19.67	26.46
10.06.	30.13	9.91	10.27	24.51	18.71
Mean	32.43	12.49	20.72	15.14	20.19
$LSD_{0.05}$ for:					
kind of living mulch					3.87
sowing term and growth suppression method					4.52
interaction I x II					9.23

c – cutting, h – herbicide treatment

The effects of growing the vegetable together with living mulches are variable depending on growing conditions and mutual relations between plants species. Living mulches compete with cultivated crops for light, moisture and nutrients and as a result of these there is often observed a yield reduction. Such results were obtained in corn growing with white clover and grasses (Nicholson & Wien 1983) and in pepper grown with white clover and perennial ryegrass (Adamczewska-Sowińska & Kołota 2001).

The results of the present study showed that intercropping tomato with living mulches caused the reduction of marketable fruit yield by 21.6% in comparison to the control. The highest yield of fruit was assured in growing tomato with serradella (48.34 t·ha^{-1}) and perennial ryegrass (47.46 t·ha^{-1}), while by 7.2-10.1% lower with white clover and pot marigold (Table 2).

Irrespective of the plant species used as living mulches, the delay of undersowing date from early to the end of April and 20 May resulted in tomato fruit increment by 14.9%, 38.2% and 51.9%, respectively. Mowing the plants sown in the first and last decade of April caused the fruit yield increment by 14.1% and 6.2%, while herbicide treatment by 10.8%. These findings are generally in agreement with statements the other authors indicating that the efficiency of such method of vegetable crops production is dependent on plant species used (Brandsaeter & Netland 1999), but to a high degree on some other factors like reduction of living mulches, growth rate by mowing and incorporating the grind pieces into the soil, herbicide treatments (Leary & De Frank 2000, Hooks & Johnson 2003), method of plant growing and time of undersowing the cover crops (Müller-Schärrer & Potter 1991).

Table 2. The marketable yield of tomato fruits depending on the plant species, sowing term and of their growth suppression method (in t·ha^{-1}), mean for 2004-2006

Sowing term of living mulch and growth suppression method	Marketable yield of tomato fruits				
	Pot marigold	Perennial ryegrass	White clover	Serradella	Mean
05.04.	28.59	41.26	37.60	44.05	37.88
05.04. + c	35.65	45.46	43.48	48.28	43.22
05.04. + h	38.54	43.47	38.70	47.14	41.96
27.04.	39.83	47.69	43.27	43.33	43.53
27.04. + c	50.16	44.78	45.09	44.97	46.25
20.05.	49.54	50.97	52.81	56.05	52.34
10.06.	61.86	60.71	52.90	54.54	57.50
Mean	43.45	47.76	44.84	48.34	46.10
control					58.79
$LSD_{0.05}$ for:					
kind of living mulch					3.10
sowing term and growth suppression method					3.56
interaction I x II					7.30

c – cutting, h – herbicide treatment

Table 3. Contents of dry matter and vitamin C in tomato fruits grown with living mulches, mean for 2004-2006

Sowing term of living mulch and growth suppression method	Dry matter (%)				Vitamin C (mg 100g^{-1} f.m.)			
	Pot marigold	Perennial ryegrass	White clover	Serra-della	Pot marigold	Perennial ryegrass	White clover	Serra-della
05.04.	6.45	6.29	6.48	6.55	31.54	21.65	27.70	25.25
05.04. + h	6.64	6.24	6.34	6.30	26.87	25.30	25.65	21.95
05.04. + c	6.10	6.28	6.50	6.33	23.25	19.70	24.00	30.40
27.04.	6.53	6.20	6.41	6.52	20.30	16.95	22.50	24.80
27.04. + c	5.94	6.47	6.19	6.36	18.35	22.40	25.60	22.90
20.05.	6.06	5.93	5.85	6.14	20.65	19.85	22.10	24.70
10.06.	5.71	6.22	6.15	6.44	21.65	21.25	22.20	26.25
Mean	6.20	6.23	6.27	6.38	23.23	21.01	24.25	25.18
Control	6.13				20.74			
$LSD_{0.05}$ for:								
kind of living mulch	n.s.				n.s.			
sowing term and growth suppression method	n.s.				n.s.			
interaction I x II	n.s.				n.s.			

c – cutting, h – herbicide treatment

Similar to the earlier study conducted by Adamczewska-Sowińska (2004) there was not observed any significant dependence between the nutritional value of tomato fruits and kind of species used as living mulch. Vitamin C content varied from 21.01 mg·100 g^{-1} fresh weight of tomato fruits grown together with perennial ryegrass to 24.25-25.18 mg·100 g^{-1} f.w. in treatment undersown by white clover or serradella (Table 3). Fruits obtained in treatments with white clover and pot marigold contained slightly higher amounts of total and reducing sugars in comparison to those grown together with perennial ryegrass or serradella (Table 4). Differentiated time of undersowing the living mulches and method of growth restriction did not influence the composition of tomato fruits.

Table 4. Contents of total and reducing sugars in tomato fruits grown with living mulches, mean for 2004-2006

Sowing term of living mulch and growth suppression method	Total sugars (%)				Reducing sugars (%)			
	Pot marigold	Perennial ryegrass	White clover	Serra-della	Pot marigold	Perennial ryegrass	White clover	Serra-della
05.04.	3.55	3.45	3.75	3.15	3.35	3.15	3.55	3.00
05.04. + h	3.65	3.55	3.50	3.10	3.40	3.20	3.25	2.95
05.04. + c	3.50	3.65	3.65	3.00	3.25	3.30	3.35	2.85
27.04.	3.90	3.55	3.45	3.05	3.75	3.25	3.30	2.90
27.04. + c	3.55	3.45	3.85	3.15	3.45	3.35	3.70	2.95
20.05.	3.75	3.50	3.75	3.35	3.55	3.20	3.55	3.10
10.06.	3.70	3.55	3.60	3.30	3.40	3.35	3.45	3.05
Mean	3.66	3.53	3.65	3.16	3.45	3.26	3.45	2.97
Control	3.51				3.26			
$LSD_{0.05}$ for:								
kind of living mulch	n.s.				n.s.			
sowing term and growth suppression method	n.s.				n.s.			
interaction I x II	n.s.				n.s.			

c – cutting, h – herbicide treatment

CONCLUSIONS

1. Marketable yield of field fruit of tomato cv. Delfine F_1 grown at stakes was in the average reduced by living mulches by 21.6% in comparison to control treatment.
2. Among tested plant species used for undersowing, seradella and perennial ryegrass were less competitive to tomatoes than pot marigold and white clover.

3. The unfavorable effects of living mulches for tomato growth and yield may by diminished by the delay date of undersowing to the time of transplanting or 3 weeks thereafter, and by mowing the plants sown in earlier terms of gliphosate treatment.
4. Chemical composition of tomato fruits was not dependent on the use of living mulches.

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WPŁYW ŻYWYCH ŚCIÓŁEK NA PLONOWANIE I JAKOŚĆ OWOCÓW POMIDORA

Streszczenie

W doświadczeniu polowym przeprowadzonym w latach 2004-2006 oceniono możliwość zastosowania żywych ściółek w uprawie pomidora odmiany Delfine F_1. Jako żywe ściółki wykorzystano koniczynę białą, seradelę, życicę trwałą i nagietek lekarski, które wysiewano na początku i pod koniec kwietnia, w dniu sadzenia rozsady (20.05.) oraz 3 tygodnie po posadzeniu roślin. Na części poletek obsiewanych w kwietniu wzrost

roślin stanowiących żywe ściółki był ograniczony przez zastosowanie glifosatu w dawce 1440 $g \cdot ha^{-1}$ (Roundup 360 SL 4 $L \cdot ha^{-1}$) lub koszenie. Rośliny pomidora prowadzono na jeden pęd przy palikach. Zbiory owoców wykonywano w okresie od końca lipca do końca września. W próbkach owoców pobranych pod koniec sierpnia oceniono zawartość suchej masy, witaminy C, cukrów ogółem i redukujących.

Wyniki przeprowadzonych badań dowiodły, że seradela i życica trwała były mniej konkurencyjne dla pomidora aniżeli koniczyna biała i nagietek lekarski. Obecność żywych ściółek na poletkach spowodowała obniżenie plonu owoców średnio o 21,6%. Niezależnie od rodzaju użytej ściółki, opóźnienie terminu jej siewu do okresu sadzenia pomidora lub 3 tygodni po posadzeniu, podobnie jak ograniczenie jej wzrostu poprzez koszenie roślin przyczyniło się do wzrostu plonu owoców. Nie stwierdzono wpływu żywych ściółek na wartość odżywczą owoców.