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Effect of Substrates with Sawdust on Yielding of Greenhouse Tomato

Wpływ podłoży z zastosowaniem trocin na plonowanie pomidora szklarniowego

Abstract. The experiment with greenhouse tomatoes was carried out in a high unheated plastic tunnel. The following substrates were tested: sawdust from coniferous trees; grey-brown podsolic soil with a 2% content of humus; sawdust mixed with soil in the ratio of 3:1; sawdust mixed with soil in the ratio of 1:1. Different nitrogen fertilization was applied at the doses of 0.8; 1.6; 2.4 g of $N \cdot dm^{-3}$ of substrate. The tomato plants were grown onto 6 clusters. The results proved the usefulness of sawdust mixed with soil in the ratio of 3:1 for cultivating the greenhouse tomatoes. Plants grown in such a substrate and fertilized with 0.8 g of $N \cdot dm^{-3}$ gave the highest yield, i.e. 5.83 kg per plant. The content of nutrients in tomato leaves did not depend on the doses of nitrogen or on the applied substrate.

INTRODUCTION

Profitability of production under cover and quality of the crops are affected by many factors, but most important is the substrate. Intensification of horticultural production makes the producers search for cheaper substrates. The most appropriate for vegetable production are substrates with good physical properties (Cebula et al., 1982; Mokrzecka, 1993, 1996 a). Slaking soils have bad water-air relations and are not useful for cultivation of vegetables (Kęsik et al., 1980).

Wood industry wastes, like sawdust of coniferous trees, can be used as uniform substrates (Sady and Nieszporek, 1984; Cebula et al., 1982; Jabłońska-Ceglarek and Dębska, 1985) or as a component of mixed substrates (Sady et al., 1982; Pudelski et al., 1982).

Advantages of sawdust as a substrate are a trace content of nutrients and similarity of properties of particular parts, which make sawdust a standard substrate. Research carried out by Bollen and Glennie (1961) proved that further decomposition of sawdust increased water capacity, and this substance has good water permeability.

Due to a wide ratio of C: N, immobilization of nitrogen may occur in the sawdust. This phenomenon can be prevented by adding an appropriate amount of nitrogen or by composting it together with nitrogen fertilizers.

Even though sawdust has many advantages that favor its use for horticultural production, there are few research papers concerning the effect of sawdust on the yielding of tomatoes under a polyethylene tunnel.

The paper describes research on the use of sawdust for preparing mixed substrates and the influence of differentiated nitrogen fertilization on the yield of tomatoes as well as on the content of nutrients in substrates and in the plant material.

MATERIAL AND METHODS

The studies were carried out on tomatoes cv. Optima which grew in 10 dm^3 containers in an unheated plastic tunnel, in 1993-1994. The experimental substrates were sawdust of coniferous trees, grey-brown podsolic soil (humus content approx. 2%) and sawdust mixed with soil in the ratio 3:1 and 1:1. Sawdust was limed using 9 g of $CaCO_3$ per dm^3. In mixed substrates, the dose of $CaCO_3$ was proportional to the amount of incorporated sawdust.

The used sawdust was stored in an open area. It contained the following amounts of nutrients ($mg \cdot dm^{-3}$): N-NO_3 — traces; P-PO_4 — 21; K — 110; Ca — 102. The value of pH in H_2O was 4.4.

The soil used for the experiments contained the following amounts of nutrients ($mg \cdot dm^{-3}$): N-NO_3 — 28; P-PO_4 — 22; K — 30; Ca — 980; Mg — 25; pH in H_2O — 7.2.

The following mineral fertilization was applied every year ($g \cdot dm^{-3}$ of the substrate): N — 0.8; 1.6; 2.4 (34% ammonium nitrate); P — 0.8 (46% superphosphate); K — 2.0 (potassium sulphate); Mg — 0.5 (magnesium sulphate). Microelements were used according to the MIS mixture — part B.

The tomato plants were headed after the 6th cluster, leaving three leaves above it; 3.5 plants grew on 1 m^2. The experiment with tomatoes was established as a completely randomized design, with 8 replications. During vegetation, side sprouts and bottom leaves were taken out. Tomato flowers were treated with growth regulator Betokson. Preventively, tomatoes were sprayed with 0.2% Brave against brown maculation of leaves. The vegetation period from seedling to the end of the experiments was 16 weeks (from May 6 till August 26).

Samples for substrate analysis were taken at the whole thickness of substrata, a month after seedling and at the time of closing up the experiment. Tomato leaves (leaf blades with petioles) were taken at the same time as soil samples.

In each term chemical analyses of the substrates were carried out by extracting them with 0.03 N acetic acid. Mineral nitrogen was analyzed with Bremner method, whereas the other available elements — with a universal method according to Nowosielski (1988). In the plant material the content of total nitrogen was determined according to Kjeldahl method while the content of nitrate nitrogen by Brenmer method, after shaking the samples with 2% acetic acid. Tomato leaves were ashed at the temperature 550°C and then the contents of phosphorus, potassium, calcium and magnesium were determined by commonly used methods.

RESULTS AND DISCUSSION

Differences in the effects that the used substrate and the differentiated nitrogen fertilization had on the plants became clear in the initial stage of vegetation. The tomatoes grown in soil had dark green leaves and that color intensified along with the increasing concentration of nitrogen in the substrate. The use of sawdust for growing the tomatoes affected both the size of plants and color of their leaves. The shortest plants with light green leaves grew at 0.8 g of $N \cdot dm^{-3}$ of substrate. A mixture of sawdust and soil in the ratio of 1:1 eliminated the differences in the effect of the increasing dose of nitrogen on the plants. Flowering of the plants and maturation of the fruit in the combinations with sawdust were 5-8 days earlier as compared to the tomatoes grown in the soil.

Results of the study (Tab. 1) proved that among various substrates used in tomato cultivation, the best in terms of yielding was the one with sawdust mixed with soil in the ratio of 3:1 and fertilized with 0.8 g of $N \cdot dm^{-3}$. In that combination the yield was the highest and equal to 5.83 kg from one plant. Similar fruit yield (5.72 kg) was gathered from tomatoes cultivated in sawdust, but fertilized with 1.6 g of $N \cdot dm^{-3}$. Calculations of the amount of nitrogen used per 1 kg of fruit were as follows: at the yield of 5.83 kg — 1.4 g of N; at the yield of 5.72 kg — 2.8 g of N. In other experiments (Starck, 1971) it was 2.5 g of $N \cdot kg^{-1}$ of tomatoes. The author's previous research

Tab. 1. Nutrient content in substrates (mg·dm^{-3}), pH, and salt concentration (means from 1993-1994)

Nutrient		Substrates											
		Sawdust			Soil			Sawdust + Soil 3 : 1			Sawdust + Soil 1 : 1		
content		N g·dm^{-3}											
		0.8	1.6	2.4	0.8	1.6	2.4	0.8	1.6	2.4	0.8	1.6	2.4
		Yield in kg·plant^{-1} NIR=LSD-0.36 kg											
		5.00	5.73	5.07	5.01	4.67	3.94	5.83	5.02	4.93	4.77	5.01	4.47
% of fruit dry matter		5.62	5.35	5.43	5.91	6.34	6.65	5.66	5.96	6.12	6.55	6.84	6.92
Mineral nitrogen	I	18	33	42	72	105	245	22	41	65	27	37	133
($N\text{-}NH_4 + N\text{-}NO_3$)	II	60	80	120	84	199	254	70	108	152	69	120	165
$P\text{-}PO_4$	I	152	196	174	240	195	193	168	173	168	173	183	226
	II	179	130	87	188	205	163	171	153	107	148	143	160
K	I	45	57	57	370	332	375	125	70	110	180	215	327
	II	245	130	110	265	380	425	320	195	185	285	200	180
Ca	I	2760	2355	2375	475	460	375	1955	2030	2200	1310	1345	1290
	II	2600	2485	2625	1110	800	700	2300	1760	1190	1275	1050	890
Mg	I	50	65	70	112	115	105	90	90	107	97	80	95
	II	175	106	127	206	195	178	179	201	149	185	191	184
pH in H_2O	I	6.9	6.9	6.9	5.3	5.2	5.3	6.5	6.7	6.6	6.5	6.3	6.0
	II	6.5	6.4	6.2	5.8	5.0	4.9	6.0	6.0	5.1	6.0	5.1	4.6
Salt concentration	I	0.51	0.54	0.60	1.23	1.54	1.78	0.49	0.57	0.81	0.57	0.91	1.74
g NaCl·dm^{-3}	II	0.60	0.92	1.49	1.83	2.20	3.39	0.84	1.47	1.80	1.41	1.77	1.98

I — analysed one month after planting
II — analysed at the end of experiment

(Mokrzecka, 1995) showed that the amount of nitrogen used for production of tomato fruit depended very much on the cultivar. The values were as follows: for Bisena cv. — 2 g of N; for Remiz — 2.1; and for Vivia — 1.4 g of N.

The yields of tomato fruit from plants grown in sawdust increased up to the dose of nitrogen 1.6 g of N·dm^{-3} and those differences were statistically significant. Similar dependencies were also found in plants grown in sawdust mixed with the soil in a ratio of 1:1; however, those differences were insignificant. Cultivation of tomatoes in other substrates caused the decrease of fruit yield with increasing nitrogen fertilization.

Tab. 2. Nutrient content in tomato leaves (% of dry matter); (means from 1993-1994)

Nutrient		Substrates											
		Sawdust			Soil			Sawdust + Soil 3 : 1			Sawdust + Soil 1 : 1		
content		N g·dm^{-3}											
		0.8	1.6	2.4	0.8	1.6	2.4	0.8	1.6	2.4	0.8	1.6	2.4
N — total	I	3.28	3.84	4.08	3.17	4.53	4.73	3.43	4.03	4.23	3.69	3.95	4.28
	II	2.15	2.26	2.36	2.36	2.60	2.78	2.39	2.52	2.79	2.43	2.60	2.63
N-NO_3	I	0.22	0.25	0.38	0.33	0.40	0.42	0.18	0.28	0.30	0.24	0.28	0.37
	II	0.10	0.16	0.20	0.15	0.21	0.29	0.11	0.17	0.20	0.12	0.19	0.22
P	I	0.31	0.29	0.34	0.33	0.39	0.35	0.31	0.33	0.33	0.29	0.37	0.41
	II	0.16	0.18	0.22	0.21	0.28	0.32	0.23	0.27	0.38	0.28	0.34	0.38
K	I	2.68	2.69	2.93	2.91	2.49	2.72	2.56	2.81	2.64	2.59	2.61	2.69
	II	1.77	2.05	1.97	1.95	1.89	1.92	1.76	2.25	2.54	2.07	2.41	2.02
Ca	I	2.02	1.87	1.81	1.70	1.17	0.98	1.68	1.52	1.37	1.52	1.15	1.33
	II	4.03	3.91	3.77	3.76	3.61	3.09	3.97	3.66	3.34	4.04	3.38	3.60
Mg	I	0.48	0.51	0.48	0.59	0.61	0.61	0.56	0.56	0.48	0.56	0.51	0.40
	II	0.67	0.67	0.56	0.69	0.79	0.51	0.83	0.77	0.80	0.98	0.98	0.87

I — analysed one month after planting
II — analysed at the end of experiment

In the present experiment, the addition of soil (at a dose of 25%) to sawdust positively influenced the improvement of physical properties of substrate. It means it improved the yielding of tomatoes, as well. The studies of Pudelski et al. (1982), Nurzyński and Mokrzecka (1980) and Mokrzecka (1993, 1996 b) indicated a positive effect of sawdust, used as a mixed substrate, on the yielding of vegetables grown in those media.

Plants grown in soil without sawdust gave the lowest yield of fruit. Mixing sawdust with soil in the ratio of 1:1 increased the yielding of tomatoes by 5% on average, as compared to tomatoes grown in soil, but the differences were statistically insignificant. Such a positive effect of sawdust mixed with soil in the ratio of 3:1 on tomato yielding also has a practical aspect. It is a very cheap substrate and it provides favorable temperature conditions, especially in the early stage of tomato cultivation in heated tunnels.

The content of dry matter in tomato fruit was affected by the substrate and the dose of nitrogen (Tab. 1). Tomatoes cultivated in sawdust mixed with soil in the ratio of 1:1 were characterized by the greatest percentage of dry matter, which was equal to 6.77%. A somewhat smaller content of dry matter was observed in plants grown in soil — 6.30%, while the smallest — 5.46% — in tomatoes cultivated in sawdust. The studies carried out by Jabłońska-Ceglarek and Dębska (1985) also showed a negative influence of sawdust on the percentage of dry matter in tomato fruit, as compared to the cultivation of those plants in soil alone. Except for the plants grown in sawdust, the increasing nitrogen fertilization positively influenced the percentage of dry matter in fruit.

It is worth noting that the effect of the substrates on the content of nutrients was different (Tab. 1). Lower concentrations of mineral nitrogen, phosphorus, potassium and magnesium were found in the substrate of sawdust. However, also in this substrate, the highest content of calcium was observed, which had been caused by incorporating a great amount of $CaCO_3$ prior to planting. Chemical analysis of the soil showed the highest content of all nutrients, except calcium. In other substrates the increasing percentage of soil increased the concentration of the above mentioned nutrients.

Increasing doses of ammonium nitrate decreased the content of phosphorus in sawdust, soil and sawdust mixed with soil (3:1); the content of potassium in sawdust and the reaction in all the studied substrates.

The content of nutrients in tomato leaves (Tab. 2) depended neither on the substrate nor on the doses of nitrogen. The only exception was nitrogen whose content in leaves increased with a higher level of fertilization with that element. Similar results were obtained in previous studies (Mokrzecka, 1996 b). While evaluating the state of plant nutrition with N, P, K, Ca, and Mg, it should be stated that it was appropriate and within the standard values (Nowosielski, 1988).

CONCLUSIONS

1. Results of the present studies proved the usefulness of sawdust mixed with soil in the ratio of 3:1 for growing the greenhouse tomatoes.
2. There were significant differences in the yield of tomato fruit. The fruit yield was the highest in plants growing in sawdust mixed with soil in the ratio of 3:1 and fertilized with 0.8 g of $N \cdot dm^{-3}$.
3. Content of nutrients in tomato leaves did not depend on the doses of nitrogen or the applied substrate.

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STRESZCZENIE

Badania przeprowadzono z pomidorami szklarniowymi uprawianymi w wysokim, nieogrzewanym tunelu foliowym. Podłożem były trociny z drzew iglastych, gleba płowa o zawartości około 2% próchnicy, trociny zmieszane z glebą w stosunku 3:1 oraz 1:1. Zastosowano zróżnicowane nawożenie azotowe w ilości: 0,8; 1,6; 2,4 g $N \cdot dm^{-3}$ podłoży. Pomidory ogłowiono za 6 gronem, pozostawiając trzy liście. Wyniki przeprowadzonych badań świadczą o bardzo dobrej przydatności trocin zmieszanych z glebą w stosunku 3:1 w uprawie pomidora szklarniowego. Rośliny rosnące w tym podłożu nawożonym 0,8 g $N \cdot dm^{-3}$ dały najwyższy plon, który wynosił 5,83 kg z rośliny. Zawartość składników pokarmowych w liściach pomidorów nie była zależna od dawek azotu, jak również zastosowanych podłoży.