

PROBLEMS OF A LONGTIME STRAWBERRY GROWING IN ONE PLOT

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Abstract. Long term investigations revealed that cultivation of strawberries (*Fragaria magna* Thuill.) for 10 years continuously in one plot reduces their vitality: the number of the produced runners decreases by 41%, of leaves – by 30%, form only 28% of inflorescence, the yield reduces by 50% in comparison with strawberries grown for two years in a new plot. Evident decline in the vitality and productivity of strawberries was detected during 4th–6th years of cultivation. Unequal reaction of the tested cultivars upon the durability of cultivation was noticed; strawberries of the cultivar ‘Senga Sengana’ reacted slightly, while the ones of the cultivar ‘Nida’ – strongly. It is related with different sensibility of these cultivars towards the disease agents of root rots.

It was determined that long-term cultivation of the *Fragaria* genus plants results in the accumulation of the parasitic fungi propagules in soil: *Ascochyta fragaricola*, *Cercospora fragariae*, *Fusarium oxysporum*, *F. solani*, *Perenospora fragariae*, *Phytophthora cactorum*, *Pythium intermedium*, *P. ultimum*, *Plasmodiophora brassicae*, *Sclerotium rolfsii*, *Verticillium alboatrum*. Therefore, cultivation of strawberries in the same plot for longer time increases the phytopathogenic potential of soil, and short interval (1–2 years) between planting has little significance upon it. The second reason for low productivity of strawberries cultivated for a long in one plot is soil tiredness caused by fungi, synthesising and excreting into surrounding toxic secondary metabolites, widespread in the rhizosphere, especially those belonging to the *Penicillium* genus: *P. janthinellum*, *P. verruculosum* var. *verrucosum*, *P. canescens*, *P. spinulosum*.

Key words: strawberry, durability of cultivation, phytopathogenic fungi, soil tiredness

INTRODUCTION

In every soil a lot of organic compounds of various chemical composition could be detected. Their origin, regularities of accumulation, abundance, and functions are difficult to determine. Some of them are produced by microscopic fungi and used as suppressers that help hamper the anti-infection mechanisms of plants thus helping the fungi to penetrate inside the organism. It can be said about some parasites from the

Cladosporium, *Phytophthora*, *Ascochyta*, *Mycosphaerella*, *Puccinia* genera [Beismann et Kogel 1995]. For a long time it was supposed that plant, responding to fungal infection, produces anti-microbial substances of low molecular weight, phytoalexins, which accumulate in the plant. Their abundance and rapidity of accumulation depend upon the efficiency of their separation from other compounds or upon the intensity of synthesis when these substances are being newly synthesised [Beili et Monsfild 1985, Kuc 1993]. Lately, together with phytoalexins, having protection functions in a plant, other plant defence factors are mentioned: proteins characterised by antibiotic properties, suppressers of endopeptidases, active forms of oxygen, glycoproteins rich in hydroxyproline, mechanical, and other barriers [Djakov et al. 2001, Mosolov et Valueva 1993, Menden et al. 1996].

From soils where plants have been grown for a longer time organic acids, ethanols, ethylene, aliphatic aldehydes, ketones, simple unsaturated lactones, naphthoquinones, anthraquinones, complex quinones, terpenes and their compounds, natural biologically active compounds of cyclopentanehydrophenanthrene – steroids, simple phenols, benzoic, cinnamonic acid, coumarins, flavanoids, various tannides, polypeptides, alkaloids and cyanohydrides, sulfides and glycosides, purines, nucleosides and plenty of other substances. Their abundance, ratio, and impact upon a plant predetermine the significance of each compound in a particular environment [Rais 1978, Rovira et al. 1979, Benken 1981, Lugauskas 1988]. Plants secrete into surrounding some of these compounds. These secretions are replenished by dead plant remnants, waste, and metabolites of other biota. All that form soil conditions suitable for the functioning of plants, and, when they are favourable, plants flourish, intensively develop roots, stems, leaves, form inflorescence and ripen fruit. However, if the above-mentioned conditions worsen, gradual slowdown of these functions is observed. This is also true regarding the cultivation of strawberries (*Fragaria magna* Thuill.) in the same plot for a longer period of time.

Each plant secretes into surrounding metabolites of a particular composition. Some compounds are detected in the secretions of different; the others are characteristic of a particular plant species. In the secretions of some plants the amount of specific compounds is much higher than in other plants. Already in 1974, E. Rais [1978] noted that certain plants, e.g., *Rhus glabra* L. accumulate in soil lactic and tannide acids that inhibit not only the growth of plants but very significantly block the functioning of microorganisms employed in nitrogen fixation and nitrification. Therefore, in such soils nitrogen deficiency becomes evident, species composition of microorganisms and plants changes.

Similar properties of the abundant secretion abundantly certain materials are also characteristic of cultivated plants. Still, these abilities are inadequately studied and usually disregarded until evident, but hardly understandable, cases of poor plant growth and yield occur. Sometimes the plant secretes extremely large amounts of the same metabolites, and the microorganisms inhabiting its rhizosphere do not have time to destroy and assimilate them; so the poisoning of plant with its own metabolites takes place; its resistance to cold weakens, immunity changes. The plant becomes more sensitive to disease agents and pests of the soil. In their rhizosphere microorganisms, producing toxic secondary metabolites, start dominating, and make the environment even less suitable for growth and functioning of plant. Soils like that are usually called genetically exhausted. The death of solitary plants was noted in these soils [Beresteckij 1978, Benken 1981].

Development of some pathogenic microorganisms in the rhizosphere of a plant starts at rather early stages of its functioning. However, when conditions are favourable for plant growth, pathogenic microorganisms do not significantly harm the plant because the plant itself and other surrounding microorganisms suppress the action of pathogens. The harm becomes evident under unfavourable meteorological conditions, in case of insufficient or surplus humidity, large temperature fluctuations, or if weeds choke the cultured plants. Consequently, the plant has to use energy to protect itself from the unfavourable environmental factors, its metabolism changes. It also causes changes in the rhizosphere: the activities of beneficial microorganisms slow down, while the disadvantageous microorganisms, some of them parasites and the agents of root rots, become more active. Fungal species, able to produce toxic secondary metabolites under such conditions, become especially abundant, thus making stronger negative impact upon plants.

Fungi – the causative agents of various diseases – are attacking the aboveground parts of the sickly plants. Plants of the *Fragaria* L. genus most often suffer from *Phytophthora fragariae* Hickman, *Plasmodiophora brassicae* Woron., *Pythium intermedium* de Bary, *P. ultimum* Trow, *Sclerotinia sclerotiorum* (Lib.) de Bary, *Fusarium oxysporum* Schl., *F. solani* (Mart.) Appel et Wollenw., *Verticillium alboatrum* Reinke et Berthold, *V. dahliae* Kab., *Phoma exigua* Desm., *Ph. lycopersici* Cooke, *Rhizoctonia solani* Kühn, *Sclerotium rolfsii* Sacc., *Mycosphaerella fragariae* (Tul.) Lindan, *Peronospora fragariae* Rozect Cornu, *Cercospora fragariae* Lob., *Ramularia graveleoma* (Tul.) Jörst., *Marssonina fragariae* (Lib.) Kleb., *Diplocarpon carlianum* (Ell. ex Ev.) Wolf., *Ascochyta fragariae* Sacc., *Phyllosticta fragaricola* Desm. et Rob., *Septoria fragariaecola* Lob., *Botrytis cinerea* Pers. [Bradenburger 1985].

In case of biotrophs, one propagule is enough to cause the infection, while necrotrophic fungi have to go through some preparation and accumulate the required amount of toxins, enzymes, and other materials necessary for the invasion into plant. Shorter or longer concealed latent period to form a new generation of offspring is required. The more abundant is the progeny, the more aggressive is the agent and vice versa [Lugauskas 1988].

Basing upon the above-mentioned, the aim was set to determine the possibilities of long-term cultivation of strawberries in one plot considering their productivity, the abundance of microorganisms and micromycete species, as well as intensity in the formation of disadvantageous phytopathogenic background and soil tiredness.

MATERIAL AND METHODS

The investigations were performed in the Experimental Farm of the Lithuanian Institute of Horticulture and Gardening with prevailing Hapli Endohypogleyic Luvisols, J₁^v. The experiment was established as follows:

- strawberries planted in soil of a new plot;
- strawberries planted in soil of such plot where they had grown for 7 years – 2 rotations. After the first rotation, the soil of this plot was lain fallow for a year, after the second rotation it was lain fallow for a year and during the second year fall rye, intended for green manure, was sown;
- strawberries were grown for ten years (three rotations).

While estimating the pathogenicity of fungi, the complex of morphological, physiological, and biochemical properties was considered. Virulence of a particular fungal strain was specified basing on its ability to infect plants of a particular genetic nature characterised by identical genes of immunity. While the aggressiveness of strains was evaluated according to the minimal amount of its infection required to injure the plant. It allowed estimating biotrophicity and necrotrophicity of fungi.

In the experimental plots three strawberry cultivars were grown; their sensitivity towards the root rot diseases, basing on the previously accumulated statistical data, was uneven: 1) 'Senga Sengana' – is widely cultivated in Lithuania and in Central and East Europe and considered resistant; 2) 'Bogota' – medium sensitive; 3) 'Nida' – sensitive.

For isolation of microorganisms from soil and their identification standard agar media were used: for fungi – malt extract, synthetic Czapek-Dox, and maize extract [Booth 1971], for *Streptomyces* – the medium of starch ammonia, for bacteria – meat-peptone agar. Numbers of the colony forming units (cfu) for bacteria and fungi were calculated in 1 g of soil dry weight (s. d. w.) [Segi 1983].

RESULTS AND DISCUSSION

Results of the investigations revealed that strawberries (*Fragaria magna* Thuill.) are sensitive to the microbiological processes in soil occurring in the cause of long-term cultivation of strawberries in soil of the same plot. It was also noticed that strawberries of different cultivars show uneven reaction towards the microbiological changes in soil. In consistency with the anticipation, most sensitive towards these changes were strawberries of the cultivar 'Nida'. These plants, growing in soil where strawberries had been cultivated for 10 years, produced by 41% less runners, by 30% less leaves, and by 28% less inflorescence comparing with the ones planted into new soil. Meanwhile, the reaction of strawberries of the 'Senga Sengana' cultivar was less evident. In exhausted soil the number of produced runners was by 19% lower, leaves by 4%, and inflorescence – by 4% lower if compared with the ones planted in the soil of a new plot. Average data of the growth of three strawberry cultivars indicate that strawberries planted in soil after 3 rotations – 10 years of constant cultivation of strawberries – grew poorer comparing with the ones in a new plot and the number of produced runners was by 19% lower, of leaves – by 14%, and of inflorescence – by 9% lower.

Strawberries planted after two rotations with a two-year interval after the second rotation grew better than those planted after three rotations without any interval, but comparing with strawberries planted in soil of a new plot the number of the produced runners was by 3% lower, of leaves – by 6%, and of inflorescence – by 5% lower. Table 1 presents the data on the changes of strawberry yield in the cause of long-term growth.

Bacteria prevailed in all tested soil samples. The longer strawberries were grown in the same plot, the higher was the number of bacteria in the soil (tab. 2), and bacteria of the genus *Mycobacterium* dominated. In the soil of the control variant little bacteria were recorded. The lowest amount of bacteria was detected in soil of the first rotation of strawberries. However, in this soil more bacteria belonged to genus *Streptomyces* were recorded. The lowest amount of streptomycetes was recorded in soil where strawberries had been grown for two rotations with intervals.

Table 1. Strawberry yield in different cultivation variants, t ha⁻¹
 Tabela 1. Plon truskawek w różnych wariantach uprawy, t·ha⁻¹

Cultivation variants Warianty uprawy	Cultivar – Odmiana			Average – Średnio	
	'Senga Sengana'	'Nida'	'Bogota'	t ha ⁻¹	%
Strawberries in a new plot Truskawki na nowym polu	12.9	9.5	10.2	10.87	100
Strawberries after 2 rotations with the interval of 1 and 2 years Truskawki po 2 rotacjach z 1- lub 2-letnią przerwą	8.6	7.9	7.2	7.90	72.7
Strawberries after 3 rotations without an interval Truskawki po 3 rotacjach bez przerwy	9.1	2.2	5.8	5.70	52.4
R _{0,5}	3.33	1.51	4.16	3.59	–

Table 2. The number of microorganism, cfu·g⁻¹ soil d. w.
 Tabela 2. Liczebność mikroorganizmów, jednostki propagacyjne·g⁻¹ s. m. gleby

Test variant Wariant testu	Bacteria Bakteria	Streptomycetes	Fungi Grzyby
Strawberries in a new plot Truskawki na nowym polu	2.5 ± 0.2·10 ⁶	1.6 ± 0.3·10 ⁵	9.5 ± 0.44·10 ⁴
Strawberries after 2 rotations with the interval of 1 and 2 years Truskawki po 2 rotacjach z 1- lub 2-letnią przerwą	1.8 ± 0.3·10 ⁶	0.8 ± 0.4·10 ⁵	10.4 ± 0.25·10 ⁴
Strawberries after 3 rotations without an interval Truskawki po 3 rotacjach bez przerwy	5.3 ± 0.8·10 ⁶	1.4 ± 0.1·10 ⁵	13.9 ± 0.21·10 ⁴
Control (without strawberries) Kontrola (bez truskawek)	3.2 ± 0.5·10 ⁶	1.0 ± 0.4·10 ⁵	8.0 ± 0.02·10 ⁴

The species of genus *Streptomyces* were divided into series according to their cultural properties [Gauze et al. 1983]. In soil of the control variant *Streptomyces* species belonging to the *Achromogenes* series dominated. However, in soil, where strawberries had been cultivated for 10 years continuously and in soil of a new plot, streptomycetes ascribed to the *Albus* series dominated. In the literature sources [Pavlovicha 1978], it is reported that streptomycetes are inhibitors of the plant growth and can be the cause for poor growth. These properties are frequently characteristic of *Streptomyces* synthesising coloured pigments from the *Violaceus*, *Roseus*, *Fradiæ* series; but in the tested soils the propagules of the above series were not abundant. Nevertheless, they were more abundant in soils where strawberries had been grown than in the soil of the control variant (tab. 3). While cultivating strawberries the changes in the abundance of some *Streptomyces* series were observed, but no significant regularities revealed.

The highest amount of the micromycete propagules was recorded in soil where strawberries had been grown for 2 or 3 rotations, the lowest amount – in soil of the control variant. All soils were characterised by a high diversity of micromycete species. Comparative analysis of micromycete species isolated from different soil samples reve-

Table 3. Systematic composition (%) of *Streptomyces* isolated from soils where strawberries had grownTabela 3. Skład (%) *Streptomyces* wyizolowanych z gleby, na której były uprawiane truskawki

<i>Streptomyces</i>	Strawberries grown in a new plot Truskawki uprawiane na nowym polu	Strawberries after 2 rotations of strawberries with the interval of 1 and 2 years Truskawki po 2 rotacjach z 1- lub 2-letnią przerwą	Strawberries after 3 rotations of strawberries without an interval Truskawki po 3 rotacjach bez przerwy	Control (without strawberries) Kontrola (bez truskawek)
<i>Albocoloratus</i>	11.6	27.4	12.8	3.8
<i>Achromogenes</i>	9.3	18.2	20.5	26.9
<i>Albus</i>	37.2	13.7	38.5	23.1
<i>Chromogenes</i>	11.6	13.7	17.9	23.1
<i>Violaceus</i>	0	9.1	0	0
<i>Fradiae</i>	4.7	9.1	2.6	0
<i>Flavus</i>	4.7	4.5	2.6	11.5
<i>Helvolus</i>	0	4.5	0	3.8
<i>Roseus</i>	1.6	0	4.5	7.7
<i>Lavendulae</i>	0	4	4.5	0

aled that the majority of fungal species isolated from the soil of the control variant do not coincide with the species isolated from soil where strawberries had been grown. Only small part of the isolated fungal species was recorded in all tested soil samples. These were typical saprophyte species belonging to the *Penicillium* Link, *Mortierella* Coem. and other genera, characteristic of Lithuanian soils. Basing on the foregoing, it could be stated that strawberries strongly influence the development of some fungi and in the cause of a longer time increase the abundance of some species in soil. It is particularly true considering micromycetes of the genera *Fusarium* Link and *Verticillium* Nees that often injure plant xylem vessels and disturb the transport of water and water-soluble materials. For this purpose the fungi employ the produced hydrolytic enzymes and toxins. And plants can start to wither, even if humidity is sufficient. Many fungi of the *Fusarium* and *Verticillium* genera saprotrophically function in soil till they enter the plant through its injured roots. Fungi widespread in soils with planted strawberries and causing root rots, such as *Pythium intermedium*, *P. ultimum* from the *Oomycetes* class, *Rhizoctonia solani* from the *Basidiomycetes* class, are ascribed to the necrotroph fungi. *Phytophthora cactorum* from the *Oomycetes* class is considered the agent of cancer injuries. These fungi settle on necrotic leaves and stems of a plant and gradually destroy them with the help of the excreted enzymes and toxins.

During the investigation, microscopic fungi ascribed to pathogens were isolated and identified from soil where strawberries had been grown (tab. 4).

In almost all soils where strawberries had been grown phytopathogenic fungi able to parasitise strawberries were recorded: *Ascochyta fragaricola*, *Cercospora fragariae*, *Fusarium oxysporum*, *F. solani*, *Perenospora fragariae*, *Phytophthora cactorum*, *Pythium intermedium*, *P. ultimum*, *Plasmodiaphora brassicae*, *Sclerotium rolfsii*, *Verticillium albo-atrum*, but their distribution and intensity of development were different. In soil of the control variant these fungi were not recorded. Their amount was also lower in

Table 4. Pathogenic fungi isolated from soil where strawberries had been grown for different cultivation variant

Tabela 4. Grzyby patogeniczne wyizolowane z gleby, na której uprawiane były truskawki w różnych wariantach uprawy

Cultivation variant Wariant uprawy	Number of isolated species Liczba wyizolowanych gatunków	Fungal species Gatunki grzybów
Strawberries grown in a new plot Truskawki uprawiane na nowym polu	14	<i>Alternaria alternata</i> (Fr.) Keissl. <i>Ascochyta fragaricola</i> L. Bertram <i>Cercospora fragariae</i> Lobik <i>Cladosporium herbarum</i> (Pers.) Link ex Gray <i>Fusarium equiseti</i> (Corda) Sacc. <i>Fusarium oxysporum</i> Schl. <i>Fusarium solani</i> (Mart.) Appel et Wollenw. <i>Phoma betae</i> (Oudem.) A. B. Frank <i>Pythium intermedium</i> de Bary <i>Pythium ultimum</i> Trow <i>Plasmodiaphora brassicae</i> Woronin <i>Rhizoctonia solani</i> J. G. Kuhn <i>Rhizopus stolonifer</i> Ehrenb. <i>Verticillium albo-atrum</i> Reinke et Berthold
Strawberries after 2 rotations with the interval of 1 and 2 years Truskawki po 2 rotacjach z 1- i 2-letnią przerwą	9	<i>Alternaria alternata</i> (Fr.) Keissl. <i>Ascochyta fragaricola</i> L. Bertram <i>Cladosporium fulvum</i> Cooke <i>Fusarium solani</i> (Mart.) Appel et Wollenw. <i>Phytophthora fragariae</i> Hickman <i>Phoma lycopersici</i> (Plowr.) Brunaud <i>Pythium intermedium</i> de Bary <i>Plasmodiaphora brassicae</i> Woronin <i>Rhizoctonia solani</i> J. G. Kuhn
Strawberries after 3 rotations without an interval Truskawki po 3 rotacjach bez przerwy	13	<i>Ascochyta fragaricola</i> L. Bertram <i>Cercospora fragariae</i> Lobik <i>Fusarium moniliforme</i> J. Sheld. <i>Fusarium oxysporum</i> Schl. <i>Fusarium solani</i> (Mart.) Appel et Wollenw. <i>Perenospora fragariae</i> (Rose et Cornu) Gaeumann <i>Phytophthora cactorum</i> (Leb. et Cohn) Schroet. <i>Pythium intermedium</i> de Bary <i>Pythium ultimum</i> Trowx <i>Plasmodiaphora brassicae</i> Woronin <i>Sclerotium rolfsii</i> Sacc. <i>Verticillium albo-atrum</i> Reinke et Berthold <i>Verticillium tenerum</i> (Nees ex Pers.) Link
Control (without strawberries) Kontrola (bez truskawek)	3	<i>Cladosporium herbarum</i> (Pers.) Link ex Gray <i>Phoma betae</i> (Oudem.) A. B. Frank <i>Rhizopus stolonifer</i> Ehrenb.

soil where strawberries had been grown with the intervals of 1 or 2 years. It must be mentioned that, shortly after planting strawberries in new plots, propagules of some phytopathogenic fungi could be already isolated, though they are not abundant; usually single colonies show up. Phytopathogenic fungi were most abundant and intensively developing in soil where strawberries had been grown for 3 rotations without an interval (10 years); their population density was also the highest. Besides, the abundance and intensity of development of phytopathogenic fungi varied in the cause of different years.

Direct dependence between their development and meteorological conditions was noticed. Some species of phytopathogenic fungi prevailed in case of surplus humidity, another – in case of insufficient humidity. During the first year of strawberry cultivation the development of phytopathogenic fungi was suppressed by functional activity of other microscopic fungi in the growing environment. When strawberries are cultivated in the same plot for a longer period of time, the diversity of fungal species decreases. In soils like that micromycetes able to synthesise and excrete secondary metabolites appear. Under conditions of the investigation *Penicillium janthinellum*, *P. verrucosum* var. *verrucosum*, *P. canescens*, *P. spinulosum*, *P. chrysogenum*, *Fusarium equiseti*, *F. oxysporum* can be attributed to these fungi. Their wider distribution and intensive functional activity could be the reasons for poor growth and yield of strawberries.

The research results confirmed that long-termed cultivation of strawberries in soil of the same plot enlarges the phytopathogenic potential of soil. A lot of identical metabolites of plant origin accumulate; they stimulate the exhaustion of soil, which is often called soil fatigue.

CONCLUSIONS

1. Strawberries are sensitive to cultivation in soil where they had been previously grown for a long time. Under such conditions strawberries produce less runners, leaves, form less inflorescence, ripen smaller berries, and produce by 50% lower yield comparing with the ones planted in new plots.

2. Strawberries planted into soil after three rotations with the interval of fallow and rye, intended for green manure, grew and yielded better because the grown plants for green manure improved the phytosanitary conditions of soil, enriched it with nutritious matter, improved physical properties, and thus lessened but did not eliminate the harm of strawberry precursor.

3. Sensitivity of strawberries to precursor is related with their sensitivity to the root rots and mycotoxins. The least harmed by long-term growing in one plot were ‘Senga Sengana’ – resistant to root rots, the most injured were ‘Nida’.

4. When strawberries are cultivated for a long time in the same plot, fungi of the species *Ascochyta fragaricola*, *Cercospora fragariae*, *Fusarium equiseti*, *F. oxysporum*, *F. solani*, *Perenospora fragariae*, *Phytophthora cactorum*, *Pythium intermedium*, *P. ultimum*, *Plasmodiophora brassicae*, *Sclerotium rolfsii*, *Verticillium albo-atrum*, parasitising plants of the genus *Fragaria*, gradually accumulate in soil. Therefore, the phytosanitary conditions of soil worsen, plants weaken, their yield decreases.

5. Another reason for poor yield and weak growth of strawberries could be wide distribution of toxin producing fungi belonging to the *Penicillium* and *Fusarium* genera in plant rhizosphere.

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PROBLEM DŁUGOTRWALEGO UPRAWIANIA TRUSKAWKI NA JEDNYM POLU

Streszczenie. Wieloletnie badania wykazały, że uprawa truskawki (*Fragaria magna* Thuill.) na jednym polu przez 10 lat spowodowała zahamowanie ich wzrostu i rozwoju. Uprawiane w ten sposób truskawki tworzą o 41% mniej rozłogów, o 30% mniej liści, o 28% mniej kwiatostanów oraz tworzą o 50% mniej owoców w porównaniu z truskawką uprawianą przez dwa lata na danym polu. Najczęściej do obniżenia wzrostu i plonowania truskawki dochodzi w 4–6 roku uprawy. Nie wszystkie uprawiane odmiany reagują jednakowo obniżeniem wzrostu i plonowania. Najmniej podatną na choroby korzeni jest odmiana 'Senga Sengana', natomiast bardziej podatna okazała się odmiana 'Nida'. Stwierdzono, że długotrwała uprawa truskawki powoduje wzrost potencjału infekcyjnego gleby, co związane jest ze wzrostem jednostek propagacyjnych takich grzybów chorobotwórczych, jak *Ascochyta fragaricola*, *Cercospora fragariae*, *Fusarium oxysporum*, *F. solani*, *Peronospora fragariae*, *Phytophthora cactorum*, *Pythium intermedium*, *P. ultimum*, *Plasmodiophora brassicae*, *Sclerotium rolfsii*, *Verticillium albo-atrum*.

W wyniku prowadzonych badań wykazano, że 1-2 letnia przerwa w uprawie truskawki nie ma większego wpływu na wzrost i plonowanie oraz porażenie roślin truskawki przez fitopatogeny.

Ponadto przy długotrwałej uprawie truskawki na tym samym polu zwiększa się liczebność grzybów z rodzaju *Penicillium*: *P. janthinellum*, *P. verruculosum*, *P. canescens*, *P. spinulosum*. Przypuszcza się, że grzyby te w strefie korzeniowej roślin tworzą związki fitotoksyczne będące produktami ich metabolizmu.

Słowa kluczowe: truskawka, długotrwała uprawa, grzyby chorobotwórcze

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