THE EFFECT OF MULCH AND MYCORRHIZA ON FRUIT YIELD AND SIZE OF THREE STRAWBERRY CULTIVARS

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A B S T R A C T

The study involved three strawberry cultivars: 'Senga Sengana', 'Kent' and 'Elsanta', planted in the spring of 2003 in a row system in the Pomological Orchard of RIPF in Skierniewice, Poland. The experiment was carried out in 2006 on 4-year-old plants as a continuation of the project Cost 631. The strawberry plants were mulched with a peat substrate, or sawdust, or pine bark, or compost or rye straw, and inoculated with a mycorrhizal preparation Mycosat. The mulches were replenished every year in the same amount during the flowering of the plants. The results of the experiments indicate that the combinations used did not, in general, cause a significant change in the yielding of plants during the experimental period presented. An exception were the plants of the cultivar 'Kent' mulched with straw, which produced a significantly lower yield, by 18.4% on average, in comparison with the control plants or those mulched with bark. Plants of the cultivar 'Elsanta' mulched with compost or sawdust were characterized by a significantly greater mean fruit weight (by an average of 1.5 g) compared with the control. On the whole, the use of the mulches and the mycorrhizal product contributed to an increase in the number of fruits of the class 'Ekstra'. Significant differences were found on the plots of 'Senga Sengana' mulched with straw or inoculated with the mycorrhizal substrate, from which, on the average, 71% more class 'Ekstra' berries were collected than from the control plants (non-mulched). The experiments confirmed the cultivar-specific differences in yield between the strawberry cultivars studied. At comparable yields, they differed significantly in terms of the number and mean weight of the fruits collected.

Key words: strawberry, mulch, mycorrhiza, yield, fruit weight

INTRODUCTION

Strawberry (Fragaria x ananassa Duch.) is one of the most delicious and fragrantly sweet flavored fruits of the world, very popular in many countries (Sharma and Sharma, 2004). Strawberry cultivation requires high labour inputs, but still enjoys great popularity. In Poland, considerable changes in strawberry production, depending on the situation on the market, are observed each year. Increasingly greater interest is being shown in the cultivation of "dessert" strawberries. This is because the prices of such fruit are often twice or even three times higher compared with those of the "industrial" varieties and they are generally easier to sell on the market (Brzozowski, 2005; Żurawicz et al., 2005).

The climate in Poland is favourable for the production of high quality strawberries. The selection of the right cultivar and growing area, harvesting at the right physiological stage, quick cooling immediately after harvest (from 24°C to 4°C in 1.5 hrs), and turnover under cold-storage conditions makes it much easier for strawberry fruits to be on the market. Fruit quality is also affected by agrotechnical treatments, i.e. mulching, irrigation, chemical protection, fertilization, and before establishing a plantation: crop rotation and intercropping, proper preparation of the field, planting date, or the health status and type of seedlings (LaMondia et al., 2002; Pawłowska et al., 2004). There are two main functions of the mulch used in the cultivation of strawberry: 1) to provide a barrier between the ground and the plants so that the berries will be kept from getting dirty and 2) to isolate them as much as possible from becoming infected with pathogenic fungi that cause the berries to rot (Rebandel, 1988). The addition of organic mulch can increase enzyme activity, but can also decrease microbial biomass (Niemi et al., 2008). Whereas, the application of vermicompost increases dehydrogenase activity and microbial biomass (Arancon et al., 2006).

Straw is the most popular mulch used in Poland for strawberry production, but synthetic mulches e.g. polyethylene films are also used (Ochmian et al., 2007). Similar studies have also been carried out in other countries with the use of natural mulches (Yavari et al., 2008; Vestberg et al., 2009), synthetic films (Haynes, 1987) and also biodegradable films of organic origin (Scarascia-Mugnozza et al., 2006, Kapanen et al., 2008, Immirzia et al., 2009).

Treder (2003) also points out other benefits of using mulches. The mulch can contribute to a considerable reduction in the evaporation of water from the soil surface. This means better water utilization by the plants. Mulch can also be used to alleviate the negative effects of a long-term draught. In the latter case, however, the best solution would be to install irrigation.

Arbuscular mycorrhizal fungi (AMF) and other microorganisms are also used in agricultural practice. Taylor and Harrier (2001) examined

the influence of AMF on the development and mineral nutrition of the strawberry plants cv. 'Elvira'. Similar investigations were also conducted by Vestberg and others (2004). They examined the influence of five microorganisms, including AM fungus *Glomus mosseae,* on the growth and health of the micropropagated strawberry.

The use of mycorrhizal fungi or organic mulches for fruit-growing can contribute to an increase in soil fertility. The use of mycorrhizal fungi or organic mulches can also reduce the use of mineral fertilizers or chemical plant protection products. This consequently leads to an improvement in the physico-chemical properties of the soil and in the quality of the fruit crop produced (Sas-Paszt et al., 2008).

MATERIAL AND METHODS

The experiment was carried out in the Pomological Orchard of the Research Institute of Pomology and Floriculture in Skierniewice, Poland, in 2006. Plants of three strawberry cultivars: 'Senga Sengana', 'Kent' and 'Elsanta', were planted in the spring of 2003 in a podsolic soil of quality class IV, at a spacing of 1.0 m x 0.25 m, using class-A frigo seedlings (crown diameter: 10-15 mm). The experiment was carried out in the third year of fruit bearing, i.e. the fourth year after planting. For each cultivar, 7 experimental combinations were applied in 3 replications, with 10 plants per replication. Spatial isolation was used between the combinations whereby the experimental plots were separated by 0.5 m wide strips of open ground.

The following combinations were used:

1. The control – plants without mulch.
2. Mulch of peat substrate.
3. Mulch of pine bark.
4. Mulch of sawdust.
5. Mulch of compost.
6. Soil-applied mycorrhizal preparation Mycosat.
7. Mulch of straw.

In the experiment, 80 litres of deacidified peat substrate, 100 litres of bark, 60 litres of sawdust and 50 litres of compost were used. The thickness of the mulch layer was about 10 cm in each combination. The mycorrhizal substrate Mycosat was applied under each plant (150 mg per plant) at the time of planting.

Plant protection was carried out in accordance with the Schedule for the Protection of Fruit Plants current at the time. The plots were drip-irrigated by means of conduits laid along the rows of the growing plants.

After the fruit harvests, the mulches were not removed, but in the spring of the following year renewed in the same amounts as described above.

The total fruit yield was determined as the overall yield from all the individual harvests. At each harvest time, the berries were divided into 3 classes: class 'Extra' (dia. > 2.5 cm), class 'I' (dia. 1.8-2.5 cm) and 'unmarketable' (dia. < 1.8 cm), and their number and weight were determined.

The results obtained were evaluated statistically with an analysis of variance. To assess the differences between mean values, Duncan's test at the 5% significance level was used.

RESULTS

The results obtained indicate that the strawberry plants of the cv. 'Senga Sengana' were characterized by significantly lower yields in comparison with the plants of the cultivars 'Kent' and 'Elsanta' (Tab. 1).

The use of the mulches and the mycorrhizal substrate did not have a significant effect on the yielding of strawberry plants as compared with the control combination. An exception here were the plants of the cv. 'Kent' mulched with straw, which produced yields at a significantly lower level in comparison with the control plants and those mulched with bark.

The number of the berries collected depended significantly on the cultivar. The highest quantities of strawberries were collected from the plants of the cultivar 'Senga Sengana', an average of 100 fewer berries from the cv. 'Kent', and about 190 fewer berries from the cv. 'Elsanta'.

The experimental combinations modified the number of berries collected from 'Senga Sengana' and 'Elsanta' plants, but did not affect the number of berries collected from the cultivar 'Kent'. In spite of this outcome, the highest numbers of strawberries, irrespective of the cultivar, were produced by the control plants. The significant differences that occurred were those associated with the use of straw, bark, compost or sawdust. Mulching the plants of 'Senga Sengana' with straw, bark and compost resulted in a significant decrease in the number of the berries collected in relation to the control plots by an average of 154 berries. Likewise, the use of compost and sawdust around the plants of the cultivar 'Elsanta' caused the collected fruit crop to be lower by 145 berries.

The statistical analysis of mean fruit weight revealed significant differences between the cultivars studied – the smallest berries were produced by the plants of 'Senga Sengana', whereas the largest were those of 'Elsanta' (Tab. 2).

The mean weight of berries was generally the lowest in the control combinations. Significant differences between the combinations were found only in the case of the cultivar 'Elsanta'. The berries of this cultivar collected from the plots mulched with sawdust or compost were characterized by a significantly greater weight, by an average of 1.5 g, in comparison with the control.

Significant differences also occurred between two types of mulches used with the cv. 'Kent' plants: the berries from the plots mulched with bark were by about 1 g heavier than the berries collected from the plots mulched with straw.

The number of strawberries classified as 'Extra' depended significantly on the cultivar. On the average, the fewest berries of this class

Table 1. Yield and the number of strawberries collected

Combination	Total yield [kg/ 10 plants]			Number of berries collected [per 10 plants]		
	Senga Sengana	Kent	Elsanta	Senga Sengana	Kent	Elsanta
Control	5.52 a-c*	6.10 c	5.91 a-c	941 h	817 f-h	730 c-g
Peat substrate	5.06 ab	5.99 a-c	5.53 a-c	818 f-h	737 c-g	613 a-c
Bark	4.99 a	6.26 c	5.96 a-c	782 e-g	749 d-g	668 a-e
Sawdust	5.25 a-c	6.04 bc	5.46 a-c	847 gh	738 c-g	566 a
Compost	5.04 ab	5.40 a-c	5.88 a-c	784 e-g	690 b-f	604 ab
Mycorrhiza	5.67 a-c	5.45 a-c	5.76 a-c	861 gh	687 a-f	662 a-e
Straw	5.07 ab	5.04 ab	5.76 a-c	794 e-g	698 b-f	639 a-d
Average	5.23 a	5.75 b	5.75 b	832.4 c	730.7 b	640. a

*The mean values marked with the same letter are not significantly different at p = 0.05

Table 2. Mean fruit weight and number of berries of Class ‘Ekstra’

Combination	Mean fruit weight [g]			Number of class ‘Extra’ berries [per 10 plants]		
	Senga Sengana	Kent	Elsanta	Senga Sengana	Kent	Elsanta
Control	5.88 a*	7.59 cd	8.13 c-f	37.0 a	090.8 c-e	096.6 c-e
Peat substrate	6.22 a	8.11 c-f	9.01 f-h	44.7 ab	103.7 de	113.4 de
Bark	6.37 ab	8.33 d-f	8.94 f-h	48.3 ab	120.4 de	119.0 de
Sawdust	6.20 a	8.16 c-f	9.65 gh	55.7 ab	122.0 de	130.0 e
Compost	6.43 ab	7.81 c-e	9.76 h	51.6 ab	088.6 cd	129.4 e
Mycorrhiza	6.58 ab	7.93 c-e	8.70 e-g	63.5 bc	111.0 de	129.0 e
Straw	6.38 ab	7.28 bc	9.01 f-h	64.0 bc	88.6 cd	112.6 de
Average	6.29 a	7.89 b	9.03 c	52.1 a	103.6 b	118.6 c

*Explanation, see Table 1

were collected from the plants of 'Senga Sengana', twice as many from 'Kent', and 2.3 times as many from the plants of the cultivar 'Elsanta'. In comparison with the control, a significant increase in the number of class 'Extra' strawberries was obtained from 'Senga Sengana' plants mulched with straw and inoculated with mycorrhizal fungi. No significant differences in the number of class 'Extra' berries were found in the other combinations.

DISCUSSION

The results relating to fruit yield and weight obtained in this experiment indicate a high usefulness of the cultivars 'Elsanta' and 'Kent' for field cultivation. In the course of the experiment, the two cultivars were characterized by significantly higher yields and higher mean fruit weight in comparison with the cultivar 'Senga Sengana'. In the experiments carried out by Małodobry and Bieniasz (1977), the cultivar 'Elsanta' was among the best-yielding cultivars, whereas in the study by Żurawicz (2005), it proved to be medium productive.

The results obtained by Sas-Paszt et al. (2008) indicate that mycorrhization of strawberry plants and mulching of the soil with a peat substrate or compost have a beneficial effect on the yield and firmness of strawberry fruits of the cv. 'Senga Sengana'. Moreover, these treatments produce positive effects on the growth of plant roots, i.e. their length, number of root tips, diameter, root surface area and volume. The results of the present experiment cannot confirm these effects in terms of yield because there were no significant differences.

The effects of mulching can be variable. Singht et al. (2008) showed that the addition of vermicompost increased plant spread, leaf area, dry matter and also increased total fruit yield. On the other hand, the addition of vermicompost drastically reduced the incidence of physiological disorders like albinism, fruit malformation and the occurrence of grey mould in strawberry production. Kęsik and Maskalaniec (2003) studied the effects of mulching on the number of strawberry fruits at harvest. Their results showed fewer berries from the plants mulched with compost or straw, more berries from those mulched with sawdust, and no effect for those mulched with bark in comparison with the control plants. Our results indicate that the mulches and mycorrhization used in our experiment caused (in the fourth year of plant growth) a decrease in the total number of strawberries at harvest, irrespective of the cultivar.

In the experiment described here, the smallest strawberries were produced by the plants of the cultivar 'Senga Sengana', and the largest by those of 'Elsanta'. The average weight of those berries for the entire harvest period was 6.3 and 9.0 g, respectively. In a study executed by RIPF, the average weight of one 'Senga Sengana' berry was in the range of 8.3-11.7 g, whereas of 'Elsanta' 8.2-15.4 g, which means that

the berries from our experiment were slightly smaller, but similar to the results of Żurawicz et al. (2003). In our opinion, the quite low mean fruit weight of the strawberry cultivars studied was associated with the age of the plants and the number of flowers. This is most often negatively correlated with the size of the fruit produced.

The mulches and mycorrhization used in the experiment increased mean fruit weight to a varying extent. Significantly higher fruit weight was obtained for the plants of the cv. 'Elsanta' mulched with sawdust or compost. An increase in this parameter of as much as 20% was achieved for the plants of the cv. 'Elsanta' mulched with sawdust or compost.

Positive results were obtained for the number of strawberries classed as "Extra". The use of the mulches or mycorrhization had contributed to an increase in the number of berries in that class obtained from the plants of 'Senga Sengana' and 'Elsanta'. A positive effect was also obtained from 'Kent' plants after using peat substrate, mycorrhiza, bark or sawdust. However, a significant increase in the number of class "Extra" berries was obtained after mycorrhization or the use of a mulch of straw, and only in the case of strawberry plants of the cv. 'Senga Sengana', for which the increase was an average of about 71%.

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CONCLUSIONS

- In comparison with the control, mulching with straw or applying the mycorrhizal substrate in 'Senga Sengana' caused a significant increase, by an average of 71%, in the number of strawberries classed as 'Extra'.
- Plants of the strawberry cultivar 'Senga Sengana' produced yields at a significantly lower level than those of 'Elsanta' or 'Kent'.
- Compared with the control plants, the use of the mulches or plant mycorrhization did not have a significant effect on the fruit yields produced by the strawberry cultivars studied.
- The cultivars in the experiment differed significantly in terms of fruit size.
- The use of sawdust or compost around the plants of the cv. 'Elsanta' caused a significant increase in mean fruit weight, by an average of 1.5 g, compared with the control.

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WPŁYW ŚCIÓŁKOWANIA I MIKORYZY NA PLONOWANIE I WIELKOŚĆ OWOCÓW TRZECH ODMIAN TRUSKAWKI

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S T R E S Z C Z E N I E

Badania przeprowadzono w 2006 roku na 3 odmianach truskawki 'Senga Sengana', 'Kent' i 'Elsanta' w Sadzie Pomologicznym ISK w Skierniewicach. Doświadczenie to było kontynuacją projektu COST 631. Czteroletnie rośliny truskawki ściółkowano substratem torfowym, trocinami, korą drzewną, kompostem, słomą żytnią oraz inokulowano substratem mikoryzowym Mycosat. Kontolę stanowiły rośliny nieściółkowane. Począwszy od 2004 roku ściółki stosowano wiosną każdego roku. Zarówno ściółki, jak i mikoryzacja roślin nie wpłynęły istotnie na wielkość plonowania badanych odmian truskawki. W porównaniu z kontrolą (bez ściółkowania), ściółkowanie słomą i mikoryzacja roślin wpłynęły na istotne zwiększenie liczby owoców klasy ekstra (o 71%) u odmiany 'Senga Sengana'. Badania wykazały różnice odmianowe roślin truskawki w wielkości plonowania. Istotne różnice po zastosowaniu ściółkowania i mikoryzacji roślin odnotowano w przypadku liczby i średniej masy owoców u badanych odmian truskawki. Ściółkowanie roślin odmiany 'Elsanta' trocinami i kompostem wpłynęło na istotne zwiększenie średniej masy owoców (średnio o 1,5 g), w porównaniu z owocami kontrolnymi

Słowa kluczowe: truskawka, ściółkowanie, mikoryza, plon, wielkość owoców