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EFFECT OF FERTILIZATION ON YIELD AND QUALITY OF CULTIVAR KENT STRAWBERRY FRUIT

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Abstract

In an experiment carried out in 2006-2007, influence of different fertilizers on yield and quality of cv. Kent strawberry fruit was determined. Two combinations were tested, each consisting of 3 types of fertilizers. The control plants remained unfertilized. In both combinations, two types of multi-component fertilizers were used (T – 5% N, 5% P_2O_5, 15% K_2O and O – 10% N, 5% P_2O_5, 10% K_2O) as well as one rate of ammonium nitrate to provide 50 kg N ha^{-1} in the first combination and 70 kg N ha^{-1} in the second one. The usage of multi-component fertilizers, especially O type resulted in an increase of cv. Kent strawberry yield. The fruit collected from the control plants and the ones fertilized with ammonium nitrate weighed less than berries obtained from plants fertilized with multi-component fertilizers. The treatment with multi-component fertilizers enhanced firmness as well as calcium, phosphorus and potassium content in fruit. The berries fertilized with higher rate of T fertilizer contained more soluble solids, total sugar and reducing sugar. Neither the type of fertilizers, nor their rate affected acidity, vitamin C, total phenol and magnesium content in berries. Higher antioxidant activity towards DPPH radicals was observed in fruit obtained from plants fertilized with lower and higher rate of ammonium nitrate. The lowest nitrogen content was observed for control berries. Practically, the differences regarding nitrogen content between the fruits of the first (50 kg N ha^{-1}) and second combination (70 kg N ha^{-1}) were negligible.

Key words: strawberry, multi-component fertilizers, fruit quality, chemical composition.

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WPŁYW NAWOŻENIA NA WYSOKOŚĆ I JAKOŚĆ PLONU TRUSKAWEK ODMIANY KENT

Abstrakt

W doświadczeniu przeprowadzonym w latach 2006-2007 określano wpływ nawozów o zróżnicowanym składzie chemicznym na plonowanie oraz jakość owoców truskawki odmiany Kent. Na tle kontroli badano 2 warianty nawożenia mineralnego, z których każdy obejmował 3 kombinacje nawozowe. W obu wariantach zastosowano posypowo dwa rodzaje nawozów wieloskładnikowych (T – 5% N, 5% P_2O_5, 15% K_2O oraz O – 10% N, 5% P_2O_5, 10% K_2O) oraz jedną dawkę saletry amonowej w taki sposób, aby dostarczyć w 1. wariancie doświadczenia 50 kg N ha^{-1}, a w 2. wariancie 70 kg N ha^{-1}. Stosowanie nawozów wieloskładnikowych, zwłaszcza typu O, spowodowało wzrost plonowania truskawki odmiany Kent. Owoce z roślin kontrolnych oraz nawożonych saletrą miały mniejszą masę niż uzyskane z zastosowaniem nawozów wieloskładnikowych. Nawozy wieloskładnikowe wpłynęły na zwiększenie jędrności i zwiększenie koncentracji wapnia, fosforu i potasu w owocach. Owoce z roślin nawożonych wyższą dawką nawozu T odznaczały się większą zawartością ekstraktu, cukrów ogółem i cukrów redukujących. Nie stwierdzono istotnego wpływu zastosowanego nawożenia na kwasowość owoców, zawartość witaminy C, polifenoli ogółem i magnezu. Wyższą aktywnością przeciwutleniającą wobec rodników DPPH odznaczały się owoce pochodzące z roślin nawożonych niższą i wyższą dawką saletry amonowej. Najmniejszą zawartość azotu miały owoce kontrolne, natomiast różnice w zawartości azotu między owocami z wariantu 1. (50 kg N ha^{-1}) i wariantu 2. (70 kg N ha^{-1}) z praktycznego punktu widzenia nie były istotne.

Słowa kluczowe: truskawka, nawozy wieloskładnikowe, jakość owoców, skład chemiczny.

INTRODUCTION

Mineral fertilization as well as cultivar, weather conditions, agronomic practice and water supply affect directly the quality of strawberry fruit (NESTBY et al. 2004). Optimal fertilization is conducive to obtaining high yield of good quality and high biological value (TREDER 2001). It is recommended to adjust fertilization to soil type, planting age and vegetation period. In spring time, strawberry plants show an increased demand mainly for nitrogen and potassium, which continues to rise during the blossom and fruit-setting phases (CIEŚLIŃSKI 2005). During the harvest, the demand for these elements declines, only to grow again afterwards (SZCZYGIEŁ, PIERZGA 2004).

The aim of the study was to estimate the influence of multi-component fertilizers on yield and quality of cv. Kent strawberry fruit.

MATERIAL AND METHODS

The experiment was carried out in 2006-2007 at the Pomological Experimental Station in Rajkowo, near Szczecin. Frigo seedlings of cv. Kent were planted in spring 2006 in a raised-bed system at 20x80 cm spacing, in three replicates, with 20 plants per plot in a split-block design. The plants were irrigated using a T-Tap dripping line. The multi-component fertilizers and ammonium nitrate were applied so as to supply a suitable amount of nitrogen to soil: 1 – 50 kg N ha^{-1}, 2 – 70 kg N ha^{-1}, and K_0 – control plots without fertilization.

Combination 1

K_1 – N-50 kg ha^{-1} (ammonium nitrate);

T_1 – 150 kg ha^{-1} (5% N, 5% P_2O_5, 15% K_2O) + 42.5 kg N ha^{-1} (ammonium nitrate);

O_1 – 200 kg ha^{-1} (10% N, 5% P_2O_5, 10% K_2O) + 30 kg N ha^{-1} (ammonium nitrate);

Combination 2

K_2 – 70 kg ha^{-1} (ammonium nitrate)

T_2 – 300 kg ha^{-1} (5% N, 5% P_2O_5, 15% K_2O) + 55 kg N ha^{-1} (ammonium nitrate);

O_2 – 400 kg ha^{-1} (10% N, 5% P_2O_5, 10% K_2O) + 30 kg N ha^{-1} (ammonium nitrate).

For the all plants under experiment, the yield per plot was determined each year. Moreover, one-fruit weight (0.01 g accuracy) and fruit firmness were measured with a FirmTech 2 apparatus (BioWorks, USA). The firmness of 100 randomly selected berries from each replicate was expressed as a gram-force causing fruit surface to bend 1 mm. Further, titratable acidity was determined by titration of a water extract of fruit homogenate with 0.1 N NaOH to an end point of pH 8.1 (measured with an Orion 720 A pH meter, USA). Soluble solids content was determined with an Abbé refractometer. L-ascorbic acid content was measured with the iodometric method (SAMOTUS et al. 1982) and expressed as mg per 100 g fruit. Total sugar and reducing sugar content was measured by Luff-Schoorl method and saccharose content was calculated (DRZAZGA 1997). The DPPH radical scavenging activity was measured spectrophotometrically at 517 nm (YEN, CHEN 1995), and DPPH$^{\cdot}$ percent inhibition was calculated according to ROSSI et al. (2003). Total phenol content was determined by the spectrophotometric metod at 760 nm, using Folin-Ciocalteu reagent and gallic acid as a standard.

The fruits were collected from each harvest and deep-frozen. After the harvest, all the samples were aggregated. Chemical analyses of macronutrients (N, P, K, Ca, Mg) were performed according to the Polish Standards.

The results were subjected to one-way analysis of variance for each year of the experiment. The means were separated by Duncan's test at significance level P = 0.05.

RESULTS AND DISCUSSION

Yield is one of the basic factors which determine profitability of production, although the quality of yield is also important. The quality of strawberry yield is a product of fruit size, firmness and chemical composition (Pelayo et al. 2003). The experiment showed that the best yields were obtained after fertilizer type O had been used. The total yield per plant expressed as a sum for 2006 and 2007 exceeded 0.4 kg (Table 1). However, in the experiment carried out by Makowska et al. (2005) cv. Kent strawberries yielded 25% better. The treatment with multi-component fertilizers resulted in obtaining fruit of the highest 100-fruit weight (Table 1). The firmness is a feature directly affecting fruit quality while calcium is a essential element for the development of hardness (Treder 2004). In turn, potassium affects water balance in plants (Cieśliński 2003). In this study, the highest firmness was found for fruit collected from the plots fertilized with multi-component fertilizers (171-193 G mm^{-1}) – Table 1. These berries were found to contain increased potassium and calcium levels compared to the berries from the plots fertilized only with ammonium nitrate.

Table 1

Yield, firmness and 100-fruit weight of cv. Kent strawberry depending on fertilization – means for 2006-2007

Fertilization	K_0	K_1	T_1	O_1	K_2	T_2	O_2
Total yield per plant (g)	366 *ab*	358 *ab*	375 *ab*	417 *b*	331 *a*	313 *a*	439 *b*
Mean weight of 100 fruits (g)	528 *a*	525 *a*	608 *bc*	591 *abc*	536 *a*	548 *ab*	645 *c*
Fruit firmness (G mm^{-1})	163 *ab*	151 *a*	193 *b*	171 *ab*	148 *a*	186 *b*	179 *b*

The two-year-long observation showed that an average soluble solids content in cv. Kent strawberries varied from 8.15% (control) to 8.85% (T_2) – Table 2. Zheng et al. (2003) determined similar content of soluble solids for cv. Allstar cultivar (8.1%). In our experiment, more total sugar and reducing sugar were found in the fruit collected from the plots fertilized with the highest rates of multi-component fertilizers (T_2 and O_2), less in the control plants (K_0) or the ones fertilized with 50 kg of ammonium nitrate per ha (K_1) – Table 2. The total sugar content in 5 cultivars of ripe strawberries studied by Cordenunsi et al. (2003) (37.3-58.8 mg g^{-1}), especially in the range of higher values, was similar to the data observed in this experiment (5.96--6.62 g 100 g^{-1}). The mean saccharose content in cv. Kent berries obtained from the plants fertilized with T_1 (1.46 g 100 g^{-1}) was higher than that of K_1 (1.14 g 100 g^{-1}), although neither differed significantly versus the berries from the other fertilization regimes. In the literature, there are reports that much greater differentiation in saccharose content in ripe fruit may

Table 2

Chemical composition of cv. Kent strawberry fruit depending on the fertilizers applied – a mean for 2006-2007

Item* Fertilization	K_0	K_1	T_1	O_1	K_2	T_2	O_2
Soluble solids (%)	8.15 *a*	8.60 *ab*	8.50 *ab*	8.25 *a*	8.55 *ab*	8.85 *b*	8.25 *a*
Total sugar (g 100 g^{-1})	5.96 *a*	6.00 *a*	6.45 *ab*	6.23 *ab*	6.43 *ab*	6.62 *b*	6.61 *b*
Reducing sugar (g 100 g^{-1})	4.63 *a*	4.80 *a*	4.91 *ab*	4.89 *ab*	5.04 *ab*	5.26 *b*	5.24 *b*
Saccharose (g 100 g^{-1})	1.27 *ab*	1.14 *a*	1.46 *b*	1.27 *ab*	1.33 *ab*	1.30 *ab*	1.30 *ab*
Titratable acidity (g citric acid 100 g^{-1})	1.11 *a*	1.15 *a*	1.11 *a*	1.09 *a*	1.13 *a*	1.13 *a*	1.11 *a*
Vitamin C (mg 100 g^{-1})	47.1 *a*	48.3 *a*	46.5 *a*	41.8 *a*	44.9 *a*	44.7 *a*	42.2 *a*
Polyphenols (mg 100 g^{-1})	405 *a*	452 *a*	424 *a*	415 *a*	440 *a*	432 *a*	437 *a*
DPPH % inhibition	24.0 *bc*	26.5 *c*	20.9 *b*	16.8 *a*	25.3 *c*	19.7 *ab*	20.7 *ab*

* The data is expressed in terms of fresh fruit.

occur between the genotypes 0.59-22.75 g kg^{-1} (KAFKAS et al., 2007). In this study, the fertilization did not exert an influence on acidity, vitamin C, and total polyphenol content in Kent berries (Table 2). On the other hand, the plants fertilized with both lower and higher rate of ammonium nitrate yielded berries of better ability to scavenge DPPH radicals compared to other treatments, except for control fruits (Table 2). In 3-year experiment SKUPIEŃ (2003) determined for Kent strawberries obtained from plantation of conventional growing procedure 8.7% of mean soluble solids content, 0.66 g malic acid 100 g^{-1}, 6.87 g 100 g^{-1} total sugar, 5.99 g 100 g^{-1} reducing sugar, 0.84 g 100 g^{-1} saccharose, 41.1 mg 100 g^{-1} vitamin C, and 218.3 mg 100 g^{-1} total polyphenol.

Table 3

Macroelements content in Kent strawberries under different fertilization

Fertilizer	Dry matter	N	P	K	Ca	Mg
	(%)	(g kg^{-1} d.m.)				
K_0	10.45 *a*	10.12 *a*	2.52 *a*	16.29 *a*	2.96 *a*	1.26 *a*
K_1	9.43 *a*	10.92 *b*	2.98 *ab*	16.58 *ab*	3.22 *a*	1.45 *a*
T_1	10.51 *a*	10.95 *bc*	3.21 *ab*	16.54 *a*	3.30 *ab*	1.28 *a*
O_1	9.86 *a*	11.64 *c*	3.26 b	17.14 *bc*	3.41 *b*	1.25 *a*
K_2	10.10 *a*	11.14 *bc*	2.84 *a*	16.04 *a*	3.17 *a*	1.39 *a*
T_2	10.45 *a*	11.56 *bc*	3.25 *b*	17.47 *c*	3.46 *b*	1.52 *a*
O_2	10.50 *a*	11.60 *bc*	3.40 *b*	16.93 *bc*	3.35 *ab*	1.31 *a*

The results presented in Table 3 show that fertilization did not affect dry matter (9.43-10.51%) and magnesium content (1.25-1.52 g kg^{-1}) in cv. Kent berries. OCHMIAN et al. (2008) determined a much higher magnesium content in cv. Senga Sengana strawberries exceeding 2.5 g kg^{-1} The use of multi-component fertilizers, especially O_1 and O_2 resulted in higher nitrogen (11.6 g kg^{-1}) and potassium (16.93-17.47 g kg^{-1}) content in fruit. The cultivar Senga Sengana berries were characterized by a higher nitrogen content, up to 28 g kg^{-1}, but the potassium content was lower, 11-14 g kg^{-1} (OCHMIAN et al. 2008). Application of O and T type fertilizers enhanced the phosphorus content in comparison to the control berries, containing less than 3 g P per kg d. m. The multi-component fertilizers enhanced the calcium content in fruit. HAKALA et al. (2003) observed similar values of K and Mg but slightly lower for Ca (on fresh weight basis) for 12 cultivars of strawberries grown under traditional and organic conditions (1.64-2.53 g kg^{-1}, 112-223 mg kg^{-1}, and 171-223 mg kg^{-1}, respectively).

CONCLUSIONS

1. Application of multi-component fertilizers, especially O type, caused an increase in the yield of cv. Kent strawberry.

2. The multi-component fertilizers improved firmness and increased the calcium content in berries.

3. Practically, the fertilization used in this experiment did not cause any considerable enhancement in the content of soluble solids, total sugar and reducing sugars in cv. Kent strawberries.

4. The fertilization applied did not affect acidity, vitamin C and total polyphenol content in the berries.

5. The fruit collected from the control plots and the plants fertilized only with ammonium nitrate showed higher ability of scavenging DPPH radicals than strawberries from the plants fertilized with multi-component fertilizers.

6. The use of multi-component fertilizers resulted in higher phosphorus and potassium concentration in fruit. The lowest nitrogen content was observed in the control fruit, while the differences between the berries from the first (50 kg N ha^{-1}) and second combination (70 kg N ha^{-1}) were not essential in practice.

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