FOLIA
HORTICULTURAE
Ann. 21/1, 2009, 17-26

Influence of varied potassium fertilization on eggplant yield and fruit quality in plastic tunnel cultivation

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Key words: dry matter, eggplant, fertilizer kind, potassium dose, sugars, vitamin C, yield

ABSTRACT

Studies upon the 'Epic F_1' eggplant were carried out in 2004 – 2005 in an unheated plastic tunnel. The eggplant was cultivated in cylinders made of rigid foil of 10 dm^3 capacity each filled with horticultural peat in 0.6 × 0.5 m spacing. The experiment consisted of two factors in a complete randomized design. The influence of the following factors was examined: 1 – potassium fertilizer kind (KCl, K_2SO_4, KNO_3); 2 – potassium dose (8, 16, 24 g K per plant). Fruit samples were harvested for laboratory analyses in the middle of August in the middle of the fruiting period. Fruits were harvested every 7-10 days at the stage of utilization maturity. Total and commercial yields as well as the number of fruits per 1 m^2 were evaluated. Fresh fruits were subjected to the following analyses: dry matter –

drying method, vitamin C – Tillmans' method, and sugars – Schoorl-Rogenbogen's method. The obtained results were subjected to analysis of variance. Different potassium fertilizers did not significantly influence yield size and structure as well as eggplant fruit number. The highest fruit yield was obtained from plants fertilized with potassium in the form of KCl at the largest dose of 24 g K per plant. No effects of potassium doses in a form of K_2SO_4 and KNO_3 on eggplant yield were observed. Instead, significant influence of varied potassium fertilization on the fruits' biological value was found. Potassium added in a form of KNO_3 at a dose of 8 g K per plant resulted in the highest dry matter and vitamin C content in eggplant.

INTRODUCTION

Besides nitrogen, potassium is a nutrient highly required by plants. It is taken by plants in a form of K^+ that is easily re-utilized at the level of the plant's tissue and organ structures. High potassium concentration in a plant affects carbohydrate accumulation (Starck 2003). Supplying the plants with potassium greatly determines the eggplant's fruit quality, therefore selecting an appropriate potassium fertilizer kind and dose is very important (Kaufmann and Vorwerk 1971, Golcz 1995, 1999, Nurzyński et al. 2001, Golcz et al. 2005).

In horticultural cultivations, only three forms of potassium fertilizers are most often used: chloride, sulfate, and nitrate. Nowadays, they are all easily available on the market, but their prices are varied, which results in high production costs due to the plants' high requirements of potassium. Various studies have revealed that the kinds of potassium fertilizers used influence yield size and quality, which results from the presence of accompanying anions, i.e. Cl^-, SO_4^{2-}, NO_3^- (Golcz 1995, 1999, Nurzyński and Michałojć 1998, Nurzyński et al. 2001).

The present study was aimed at evaluating the influence of potassium fertilizer kind and dose on eggplant yield as well as contents of dry matter, vitamin C, and sugars.

MATERIAL AND METHODS

Studies upon the 'Epic F_1' eggplant were carried out in an unheated plastic tunnel in 2004 – 2005 in The Felin Experimental Farm (University of Life Sciences in Lublin). The eggplant seedlings were prepared in a greenhouse in 8 cm diameter pots on horticultural subsoil according to recommendations for that plant species. In both years of the study, seedlings were planted into the tunnel at the beginning

of June. The period between seed sowing and the end of cultivation lasted about seven months (beginning of March – middle of September).

The eggplants were set in 0.6 × 0.5 m spacing in cylinders made of rigid plastic of 10 dm^3 capacity each and filled with horticultural peat (initial pH 4.6), which was limed using $CaCO_3$ to pH 6.5. The experiment was set as bi-factorial in a complete randomized design.

The following factors were studied:

– Potassium fertilizer kind: KCl; K_2SO_4; KNO_3,
– Potassium dose: 8, 16, 24 g K per plant.

Each combination was represented by eight experimental units.

The following fertilization was applied (g per plant): N 11 (in a form of NH_4NO_3 – 34% N); P 7.0 (in a form of $Ca(H_2PO_4)_2 \cdot H_2O$ – 20.2% P); K 8, 16, or 24 (in a form of KCl – 50% K, K_2SO_4 – 41.6% K, or KNO_3 – 37.4% K, 15% N), Mg 6.0 (in a form of $MgSO_4 \cdot H_2O$ – 17.4% Mg). Microelements were applied in forms of: EDTA – Fe, $CuSO_4 \cdot 5H_2O$, $ZnSO_4 \cdot 7H_2O$, $MnSO_4 \cdot H_2O$, H_3BO_3, $(NH_4)_2Mo_7O_{24} \cdot 4H_2O$ at amounts similar for peat subsoil. Before plant setting, microelements were completely applied, phosphorus in its half amount, while nitrogen, potassium, and magnesium in their 1/7 rates. The remaining N, K, and Mg amounts were applied in six doses every 10 days.

Plants were not trained and fruits were harvested at the stage of marketable maturity determined by intensive purple colour and characteristic metallic glow (fruit weigh ranged from 250 to 300 g) separately from each plant. The harvest was performed every 7-10 days from the end of July till the middle of September. The total and marketable fruit yields as well as number of total and marketable fruits per 1 m^2 were determined.

Fruit samples for laboratory analyses were collected in the middle of August in the middle of the fruiting period. The following items were determined in freshly harvested fruits: dry matter – drying method, vitamin C – Tillmans' method, and sugars – Schoorl-Rogenbogen's method. All determinations were made in three replications.

The results were statistically verified using analysis of variance, the significant differences were evaluated using the Tukey's test at $p = 0.05$.

RESULTS AND DISCUSSION

Due to a lack of significant differences of yield size and its particular components between study years, the results are presented as mean values of 2004 – 2005.

Results related to eggplant fruit yield structure are presented in Table 1.

Table 1. Yield structure of 'Epic F_1' eggplant (mean values for 2004 − 2005)

Kind of K fertilizer	Potassium dose (g K per plant)	Yield (kg m^{-2})		Marketable yield in total yield (%)	Number of fruits per m^2		Marketable fruit number in total fruit number (%)
		Total	Marketable		Total	Marketable	
KCl	8	3.73	3.34	89.5	17.5	12.5	71.4
	16	4.95	4.52	91.3	21.6	17.5	81.0
	24	5.69	5.38	94.6	24.4	19.4	79.5
Mean for KCl		4.79	4.41	92.1	21.2	16.5	77.8
K_2SO_4	8	4.60	3.99	86.7	22.7	17.5	77.1
	16	4.57	4.24	92.8	22.1	17.9	81.0
	24	4.62	4.11	89.0	21.0	16.0	76.2
Mean for K_2SO_4		4.60	4.11	89.4	21.9	17.1	78.1
KNO_3	8	4.37	3.88	88.8	20.8	16.2	77.9
	16	4.88	4.67	95.7	21.8	18.9	86.7
	24	4.23	4.07	96.2	17.5	16.2	92.6
Mean for KNO_3		4.49	4.21	93.7	20.0	17.1	85.5
Mean for K dose	8	4.23	3.74	88.4	20.3	15.4	75.9
	16	4.80	4.48	93.3	21.9	18.1	82.6
	24	4.85	4.52	93.2	21.0	17.2	81.9
Total mean		4.63	4.25	91.8	21.1	16.9	80.1
$LSD_{0.05}$							
kind of K fertilizer		n.s.	n.s.		n.s.	n.s.	
K dose		n.s.	0.700		n.s.	n.s.	
interaction		1.706	1.609		n.s.	n.s.	

In 2004 – 2005, the mean total and marketable yields were 4.63 and 4.25 kg m^{-2}, respectively. The variance analysis did not show a significant influence of potassium fertilizer kind on total and marketable yields, and even on the number of quality fruits in total and marketable yields. Regardless of the potassium fertilizer dose, the average marketable yield was as follows: KCl – 4.41 kg m^{-2}, K_2SO_4 – 4.11 kg m^{-2}, and KNO_3 – 4.21 kg m^{-2}.

A significant influence of potassium dose on mean marketable yield of eggplant fruits was recorded regardless of the kind of potassium fertilizer used. Significantly, the lowest fruit yield of marketable quality was obtained when applying the lowest potassium dose (8 g K per plant – 3.74 kg m^{-2}) in reference to yield at doses of 16 and 24 g K per plant (4.46 and 4.52 kg m^{-2}, respectively). It should be also mentioned that a significantly higher marketable quality yield of eggplant fruits was obtained when applying potassium chloride at its highest dose as compared to that from plants fertilized with the lowest K doses.

The share of marketable yield in the total yield indicated that after applying 8 g K per plant, lower values of that parameter were recorded (88.4%) than at higher potassium doses (Table 1).

Variance analysis did not reveal a statistically significant effect of the examined factors on the number of total and marketable fruits harvested from 1 m^2. The lowest potassium dose reduced the share of marketable yield in total fruit number by about 6% as compared to the higher potassium level in fertilizer applied.

The studies carried out in 2004 and 2005 revealed a mean marketable yield of 4.25 kg m^{-2}, which was similar to the results obtained by others (Gajewski and Gajc-Wolska 1998, Kowalska 2003, Michałojć and Buczkowska 2007). Golcz and Markiewicz (2003) obtained a higher fruit yield. Different potassium fertilizers had no significant influence on the yield size of eggplant fruits cultivated in peat substrate. In the available literature, there is no information on the effects of various potassium fertilizer forms on eggplant fruit yield. However, one can refer to the study by Nurzyński et al. (2001) dealing with sweet pepper, in which fruit yield did not significantly differ when K_2SO_4, KCl, and KNO_3 were applied. Here, no significant influence of the potassium dose applied in a form of K_2SO_4 and KNO_3 on fruit yield was observed, except from KCl. Golcz (2001) found no effects of potassium dose on pepper yield. It should be underlined that in the present study, the highest eggplant fruit yield was obtained at the highest potassium dose in a form of KCl, which can prove its usefulness for fertilizing eggplant plants cultivated in peat substrate.

The biological value of the eggplant was evaluated on the basis of dry matter, vitamin C, total sugars, and sucrose contents in fresh fruits. Results are presented in Table 2.

Table 2. Content of dry matter, vitamin C, total sugars, and sucrose in eggplant fruits (mean values for 2004 − 2005)

Kind of K fertilizer	Potassium dose (g per plant)	Dry matter (%)	Vitamin C (mg 100 g^{-1} f.m.)	Total sugars (% f.m.)	Sucrose (% f.m.)
KCl	8	7.80	4.39	2.58	0.12
	16	7.72	4.10	2.36	0.12
	24	8.48	3.69	2.61	0.13
Mean for KCl		8.00	4.06	2.52	0.12
K_2SO_4	8	7.48	4.20	2.72	0.26
	16	7.67	3.74	2.71	0.24
	24	7.65	3.72	2.54	0.23
Mean for K_2SO_4		7.60	3.89	2.66	0.24
KNO_3	8	7.82	4.38	2.72	0.13
	16	7.40	4.08	2.72	0.30
	24	6.95	4.08	2.75	0.21
Mean for KNO_3		7.39	4.18	2.66	0.21
Mean for K dose	8	7.70	4.32	2.67	0.16
	16	7.60	3.97	2.60	0.22
	24	7.69	3.83	2.56	0.19
Total mean		7.66	4.04	2.61	0.19
$LSD_{0.05}$					
kind of K fertilizer		0.122	0.044	0.092	0.024
K dose		n.s.	0.044	0.092	0.024
interaction		0.283	0.103	0.170	0.072

Dry matter content ranged from 6.96% to 8.48%, with a mean value of 7.66%. Studies performed by Kaufmann and Vorwerk (1971), Herrmann (1996), Gajewski (2002), Kowalski et al. (2003) revealed similar contents of dry matter. In this study a significant influence of different potassium fertilizers on the studied parameter was observed. Regardless of the potassium dose, the highest dry matter amount was found in fruits of plants fertilized with potassium chloride (8.00%), then potassium sulfate (7.60%), and the lowest when using potassium nitrate (7.39%). The variance analysis did not show a significant effect of potassium dose in the form of sulfate on dry matter content in eggplant fruits. Instead, the influence of potassium doses in the forms of KCl and KNO_3 was recorded. Increasing the potassium dose lowered dry matter content in fruits (Table 2). Similar relations can be found in studies of Golcz (1999) upon pepper.

Eggplant, as compared to pepper, is a vegetable with low vitamin C content. Vitamin C content ranged from 3.69 to 4.39 mg 100 g^{-1} fresh matter with a mean value of 4.04 mg 100 g^{-1} fresh matter for eggplant fruits. Similar vitamin C concentrations in eggplant were found by Cebula (1996) – 5.54 mg 100 g^{-1} fresh matter, Gajewski and Gajc-Wolska (1998) – 5.89 mg 100 g^{-1} fresh matter, or Gajewski (2002) – 3.6-6.2 mg 100 g^{-1}. Kowalski et al. (2003) found much higher

vitamin C content in 'Epic F_1' eggplant – 9.5-23.2 mg 100 g^{-1} fresh matter. In this study the influence of the studied factors on vitamin C content in eggplant fruits was found. Its highest amounts were determined in fruits of plants fertilized with KNO_3, less with KCl, and the least with K_2SO_4 (Table 2). Considering all of the applied potassium fertilizers, it was found that the decrease of potassium content in fruits was observed along with potassium dose increase. In any available studies no reports referring to the influence of varied potassium fertilization on eggplant have been found. The studies only revealed the tendency indicating the effect of increasing potassium rates on vitamin C concentrations (Golcz 1995).

Referring to carbohydrates in fresh fruit matter, total sugar content was 2.61%, on average. Similar sugar levels in eggplant fruits were reported by Herrmann (1996), Lavande and Chavan (1998), as well as Stachowiak et al. (2003), while almost twice as much by Gajewski (2002) and Kowalski et al. (2003). In this study, a significant influence of the studied potassium kind on total sugar content was proven. Statistically, the higher content was found in fruits of plants fertilized with K_2SO_4 and KNO_3 as compared to those amended with KCl. The effect of potassium dose on the studied parameter was not univocal (Table 2). Due to a lack of information on the influence of varied potassium doses on total sugar content in eggplant, the obtained results were compared to results from Nurzyński et al.'s (2001) research on pepper, revealing similar dependencies.

The mean sucrose content in fresh eggplant fruits was 0.19% of fresh matter. Potassium chloride at varied doses significantly affected the decrease of sucrose content. Other potassium fertilizers invoked a more than two-fold sucrose concentration increase in fruits; however, no univocal dependence between potassium doses and sucrose amount was recorded. Stachowiak et al. (2003) and Herrmann (1996) observed similar sucrose contents in their studies, while Savvas and Lenz (1994) found it to be higher. Nevertheless, low carbohydrate content in eggplant fruits can prove that the plant is low-caloric and contains high levels of minerals, particularly potassium (Michałojć and Buczkowska 2008).

CONCLUSIONS

1. Different potassium fertilizers had no significant influence on the size and structure of eggplant fruit yield.
2. The highest fruit yield was obtained from plants fertilized with potassium in kind chloride at 24 g K per plant dose. No effects of potassium dose in kind of potassium sulphate and potassium nitrate on eggplant yield were found.
3. A significant influence of varied potassium fertilization on fruit biological value was confirmed. The highest contents of dry matter and vitamin C were found after applying potassium nitrate at the dose of 8 g K per plant.

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WPŁYW ZRÓŻNICOWANEGO NAWOŻENIA POTASEM NA PLON I JAKOŚĆ OWOCÓW OBERŻYNY W UPRAWIE POD FOLIĄ

Streszczenie: Badania z oberżną odmiany 'Epic F_1' wykonano w latach 2004 – 2005 w nieogrzewanym tunelu foliowym. Oberżynę uprawiano w cylindrach z folii sztywnej o pojemności 10 dm3, w torfie ogrodniczym w rozstawie 0,6 × 0,5 m. Doświadczenie przeprowadzono jako dwuczynnikowe w układzie kompletnej randomizacji. Badano wpływ czynników: 1 – nawozów potasowych (KCl, K_2SO_4, KNO_3); 2 – dawek potasu (8, 16, 24 g K na roślinę). Próby owoców do badań laboratoryjnych pobrano w 2 dekadzie sierpnia, w połowie okresu owocowania. Owoce zbierano sukcesywnie, co 7-10 dni, w fazie dojrzałości użytkowej. Określono plon ogółem i handlowy oraz liczbę owoców z 1 m^2. W świeżych owocach oznaczono zawartość suchej masy metodą suszarkową, witaminę C wg Tillmansa, cukry wg Schoorl-Rogenbogen. Uzyskane wyniki poddano analizie wariancji. Zróżnicowane nawozy potasowe nie miały istotnego wpływu na wielkość i strukturę plonu oraz liczbę owoców oberżyny. Największy plon

owoców uzyskano z roślin nawożonych chlorkiem potasu w dawce 24 g K na roślinę. Nie stwierdzono natomiast wpływu dawki potasu w postaci siarczanu potasu oraz saletry potasowej na plon oberżyny. Wykazano istotny wpływ zróżnicowanego nawożenia potasem na wartość biologiczną owoców. Największą zawartość suchej masy i witaminy C wykazano po nawożeniu potasem w postaci saletry potasowej w dawce 8 g K na roślinę.

Received November 4, 2008; accepted June 9, 2009