EFFECT OF FOLIAR SPRAYS ON POTASSIUM, MAGNESIUM AND CALCIUM DISTRIBUTION IN FRUITS OF THE PEAR

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A B S T R A C T

The paper presents the results of chemical analyses of different parts of 'Conference' pears. The trees were treated with different foliar fertilizers (calcium chloride, Kalcisal, Kalcisal+Kalcifos, Sanisal A and Sanisal B). The treatments consisted of five foliar sprays (at the rate of 0.5%) at two week intervals followed by five (at the rate of 1.0%) at one week interval. After 120 days of storage, treated fruits were washed and each fruit was divided into: peel, calyx end, stem end, and outer part of flesh.

The highest concentration of macroelements was found in the peel, whereas the lowest – near the calyx, and in the outer part of flesh. Although the foliar fertilizers significantly affected the fruit calcium content, in some cases the beneficial influence of using fertilizers was not evident. Compared to the control, higher calcium concentration was found only in fruits from trees treated with Kalcisal and Sanisal B. The highest differentiation in the calcium content was observed in the peel samples.

K/Ca ratio ranged from 15 to 35. The highest ratios were noted for fruits from trees treated with Kalcisal+Kalcifos and Sanisal A (31 and 35, respectively). In the case of this index, no differences between control fruits and the other treatments were found. All of the calculated cation ratios were the lowest when the peel was analyzed, whereas in the rest of the examined fruit parts only the differences between the Mg/Ca ratio were significant.

Key words: pear, foliar fertilizers, fruit mineral composition, K/Ca ratio, fruit quality

INTRODUCTION

Fruit quality maintenance is strongly influenced by preharvest environmental factors. Weather conditions have a great impact on flowering, pollination, fruit set and fruit mineral composition (Tromp, 1978; Shear 1980;

Atkinson et al., 1995; Neilsen and Neilsen, 1997). Preharvest nutritional status of fruit, especially in respect to calcium, is an important factor affecting potential storage life (Fallahi et al., 1997). Fruits with a high level of calcium have lower respiration rate and longer potential storage life than fruits containing low calcium. Many physiological disorders in fruits are associated with calcium deficiency. Some authors attribute physiological disorders in the calcium ratio to other nutrients in the fruit (Sharples, 1980; Marcelle, 1995). The easiest way to maximize fruit calcium level is a foliar spray. However, in many cases, it is very difficult to achieve because of the restricted uptake and penetration of calcium into the fruit and its movement within fruit tissue (Mengel, 2002).

Therefore, the aim of this study was to evaluate the penetration of different calcium fertilizers. Moreover, the distribution of calcium, potassium and magnesium in different parts of pears were analyzed.

MATERIAL AND METHODS

In 2004 year the field experiment was conducted in pear orchard at the Experimental Station in Garlica Murowana, near Cracow. The soil of the plot where the fruit trees were planted was in the valuation class II b. It is classified as a brown soil type developed from loess and represents a type described as silt loam. In the middle of July soil samples were taken for analysis, separately from the herbicide strips (HS), grass strips (GS), as well as from the layers of 0-20 and 20-40 cm in depth. Soil pH was determined in H_2O and 1 M KCl. Potassium, magnesium and calcium were extracted according to the universal method (with 0.03 M CH_3COOH) and measured by atomic absorption spectrophotometry (Ostrowska et al., 1991). Soil properties are presented in Table 1.

Table 1. Some soil properties of the experimental orchard

		pH_{H2O}	pH_{KCl}	K	Mg	K/Mg	Ca
Herbicide/ Grass strips	HS	5.22	4.23	99.3	61.8	1.6	452.6
	GS	6.19	5.36	129.0	84.8	1.5	610.4
Soil layer depth [cm]	0-20	5.83	4.96	146.5	83.6	1.7	542.0
	20-40	5.58	4.63	81.8	63.0	1.3	520.9

The plant material was composed of 15-year old ‘Conference’ trees grafted on *Pyrus caucasica* rootstock. In the orchard, the soil cultivation system was a herbicidal fallow in rows and grass in the inter-rows. The pear

trees were spaced 3.0 × 4.0 m. The crowns of trees were trimmed in a spindle form. The protection of the trees was carried out according to the recommendations accepted for commercial orchards.

The experiment was established in a randomized block design, each treatment being represented by five replications – plots of two trees each. The following treatments were used in the experiment:

1. Control – trees sprayed with water,
2. Calcium chloride,
3. Kalcisal (11% Ca, 0.1% Mg, 0.02% B),
4. Kalcisal+Kalcifos (2% Ca, 18% P, Mg 0.1%, 0.02% B),
5. Sanisal A (kaolin clay),
6. Sanisal B.

The treatments consisted of five foliar sprays (at the rate of 0.5%) at two week intervals followed by five (at the rate of 1.0%) at one week interval. A few days before commercial harvest time the samples of fruits were taken. Twenty fruits per tree were picked from the outside middle canopy. After 120 days of storage, fruits from the treatments were washed and ten pears were taken for analyses. Stems and seeds were removed. Each fruit was divided into: peel, calyx end, stem end, and outer part of flesh. Each part of fruit was mineralized separately in a mixture of HNO_3:$HClO_4$:H_2SO_4 (6:2:0.25) and analyzed using atomic absorption spectrophotometry (AAS) to assess the content of potassium, magnesium and calcium.

The measurements were listed and subjected to analysis of variance. Differences between the means were ascertained with a multiple Duncan Test, using a Statistica 6.0 program. The mean values for the combinations labelled with the same letters do not significantly differ at the significance level P=0.05.

RESULTS AND DISCUSSION

The investigated foliar fertilizers significantly affected fruit mineral content (Fig. 1, Tab. 2). The measured amounts of potassium, magnesium and calcium in pears were similar to values presented by Schulz (1996). After the use of Kalcisal, Kalcisal + Kalcifos and Sanisal A, a higher fruit potassium content was observed. Except for $CaCl_2$, all treatments increased the magnesium content in comparison to the control fruits. The estimated magnesium content ranged from 81.0 to 90.4 mg kg^{-1} in treated fruits and was 71.1 mg kg^{-1} Mg in control fruits. However, of the elements investigated, the biggest difference in content was observed for calcium. Pears from trees sprayed with Kalcisal and Sanisal B had a higher calcium level (125.5 and 125.9 mg kg^{-1} calcium, respectively), whereas control fruits reached 108.8 mg kg^{-1} Ca. On the contrary, no beneficial effect in the calcium increasing, after the use of $CaCl_2$, Kalcifos+Kalcisal and Sanisal A was observed.

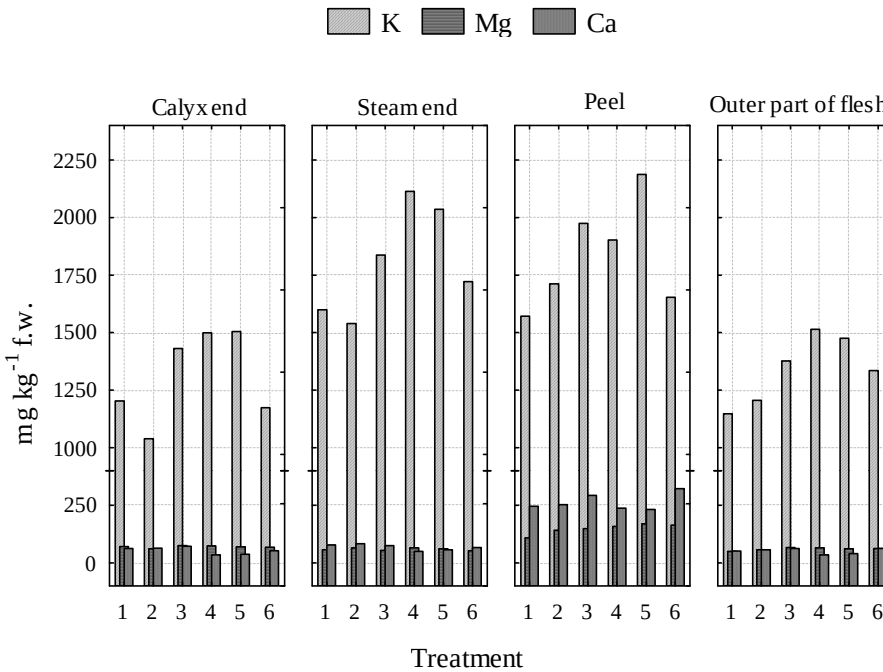

Figure 1. K, Mg and Ca content [mg kg^{-1} f.w.] measured in different parts of fruit

Table 2. K, Mg and Ca fruit content [mg kg^{-1} f.w.] as affected by different foliar fertilizers (mean values)

Treatment	K [mg kg^{-1} f.w.]	Mg [mg kg^{-1} f.w.]	Ca [mg kg^{-1} f.w.]
Control	1380 a*	71.1 a	108.8 b
$CaCl_2$	1374 a	81.0 ab	113.8 bc
Kalcisal	1655 b	86.1 b	125.5 c
Kalcisal + Kalcifos	1757 b	90.3 b	89.1 a
Sanisal A	1800 b	90.4 b	91.6 a
Sanisal B	1471 a	86.7 b	125.9 c

*Means designated with the same letter do not differ at significance level P=0.05

The part of fruit analyzed had a great impact on the content of investigated macroelements (Tab. 3). The potassium content was the highest in peel and stem end of investigated fruits (1833 and 1808 mg kg^{-1} K, respectively), whereas in outer flesh and calyx end only 1342 and 1308 mg kg^{-1} K were recorded. With magnesium and calcium content, the differences between peel and the rest of fruit parts were strongly evident. The estimated peel magnesium content reached 148.5 mg kg^{-1}, in other parts ranged from 59.1 mg kg^{-1} Mg (stem end) – 69.6 mg kg^{-1} Mg (calyx end). However, the

biggest differences between the analyzed fruit parts were noted for calcium. Calcium level measured in the peel (263.8 mg kg^{-1} Ca) was four to five times higher than in the remaining parts of fruit (Fig. 1, Tab. 3). Wieneke (1969) and Ben and Koszorz (2004) pointed out that the concentration of calcium went down from stem to calyx end of apple. The reverse pattern for magnesium was reported by Lewis and Martin (1973). The experiment confirmed these findings in respect to pears.

Table 3. K, Mg and Ca fruit content [mg kg^{-1}] in different part of 'Conference' pears

	K [mg kg^{-1} f.w.]	Mg [mg kg^{-1} f.w.]	Ca [mg kg^{-1} f.w.]
Peel	1833 b*	148.5 c	263.8 c
Stem end	1808 b	59.1 a	67.9 b
Outer part of flesh	1342 a	59.9 a	51.1 a
Calyx end	1308 a	69.6 b	53.7 a

*For explanation, see Table 2

The foliar fertilizers strongly influenced the calcium peel content (Fig. 1). A higher level of calcium was found for pears treated with $CaCl_2$ and Sanisal A.

The K/Ca ratio varied between 15 and 35 and it was higher for pears from trees fertilized with Kalcisal+Kalcifos and Sanisal A (35 and 31 K/Ca, respectively). However, no significant differences between the control and fruits treated with $CaCl_2$, Kalcisal and Sanisal B were observed. In the case of Mg/Ca ratio the control fruits had this index higher (2.5 Mg/Ca) in comparison to treated fruits. Of all the fertilizers used in this study, the higher Mg/Ca ratio was obtained for Sanisal A and Kalcisal+Kalcifos (1.3 and 1.5, respectively), whereas for $CaCl_2$, Kalcisal and Sanisal B – the lower (0.8-0.9 Mg/Ca).

Table 4. The ratios between the analyzed macroelements in 'Conference' pears as influenced by different foliar sprays (mean values)

Treatment	K/Ca	Mg/Ca	(K+Mg)/Ca
Control	15 a*	2.5 c	18 a
$CaCl_2$	16 a	0.8 a	17 a
Kalcisal	18 a	0.8 a	19 a
Kalcisal+Kalcifos	35 b	1.5 b	36 c
Sanisal A	31 b	1.3 b	31 b
Sanisal B	19 a	0.9 a	20 a

*For explanation, see Table 2

As far as K+Mg/Ca ratio is concerned, the relations were similar to those obtained for Mg/Ca. As Lafer (1995) reported, the best values for this index are < 20, whereas > 30 decreases the potential storage life. The highest values of this index were noted for Kalcisal+Kalcifos and Sanisal A (36 and 31,

respectively). The only exception were non treated fruits, in which the K+Mg/Ca ratio was low (Tab. 4).

All of the ratios: K/Ca, Mg/Ca and (K+Mg)/Ca were the lowest in the peel (7.0, 0.6, and 8.0, respectively). The proportion between K/Ca in the rest of the analyzed fruit parts ranged from 26 to 28 and did not vary (Tab. 5, Fig. 2). The same relation was observed for the Mg/Ca ratio, for calyx, stem end and flesh this index varied from 28 to 30. Differences between all of the analyzed fruit parts were significant only for the Mg/Ca ratio.

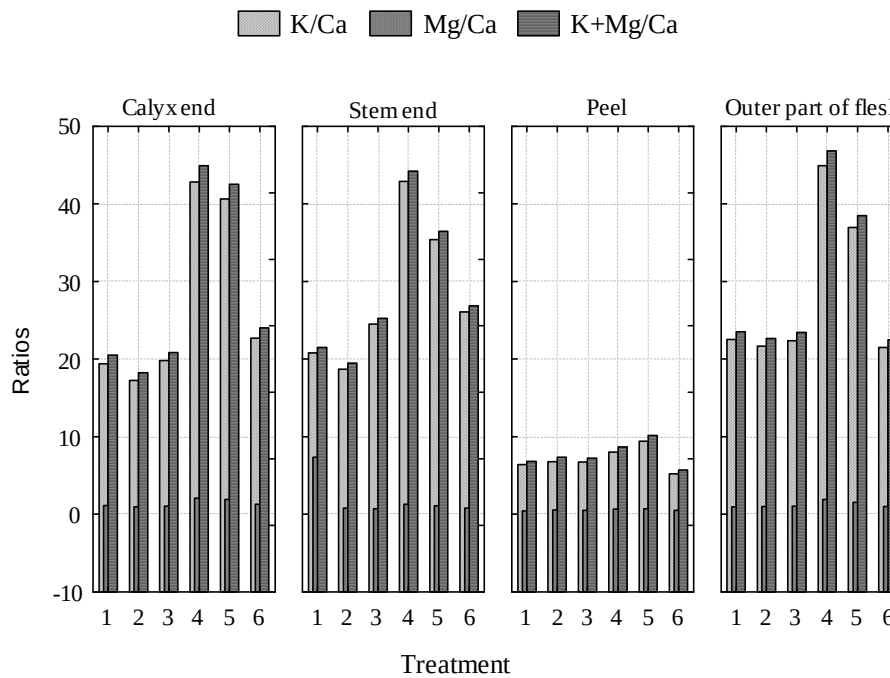

Figure 2. K/Ca, Mg/Ca and (K + Mg)/Ca ratios calculated for different parts of 'Conference' fruits

Table 5. The ratios between analyzed macroelements in 'Conference' pears as influenced by different part of fruit

	K/Ca	Mg/Ca	(K+Mg)/Ca
Peel	7 b*	0.6 a	8 b
Basal end	26 a	2.0 d	28 a
Outer part of flesh	28 a	1.2 b	30 a
Calyx end	27 a	1.4 c	28 a

*For explanation, see Table 2

The highest Mg/Ca ratio was found for stem end (2.0), whereas the lowest – in the outer flesh.

CONCLUSIONS

1. Foliar sprays with Kalcisal and Sanisal B increased calcium fruit content. The other treatments investigated did not improve calcium level.
2. The highest concentration of investigated macroelements was noted in the peel of fruits, whereas the lowest - near the calyx, and in the outer part of flesh.
3. The K/Ca ratio varied between 15 and 35 and was higher in pears from trees fertilized with Kalcisal+Kalcifos and Sanisal A (35 and 31 K/Ca, respectively).

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WPŁYW NAWOŻENIA DOLISTNEGO NA ROZMIESZCZENIE POTASU, MAGNEZU I WAPNIA W OWOCACH GRUSZY

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

Przedstawiono wyniki analiz składu mineralnego różnych części owoców gruszy odmiany ‘Konferencja’. Drzewa traktowano nawozami dolistnymi: chlorkiem wapnia, Kalcisalem, Kalcisalem z Kalcifosem oraz preparatami Sanisal A i Sanisal B. Zabiegi wykonywano od czerwca do września w odstępach dwutygodniowych (5 oprysków 0,5% roztworem), a następnie tygodniowych (5 oprysków 1% roztworem). Owoce poddano analizie po 120 dniach przechowywania. Osobno analizowano skórkę, a miąższ dzielono na części – przykielichową, środkową i przylegającą do szypułki.

Najwyższa zawartość analizowanych makroelementów była w skórce, a najniższa w części środkowej i przykielichowej miąższu. Istotny wzrost zawartości wapnia był w owocach dokarmianych Kalcisalem i Sanisalem B. Największe zróżnicowanie w zawartości wapnia obserwowano w próbkach skórki owoców.

Stosunek K/Ca wynosił od 15 do 35. Najwyższą wartość dla tego współczynnika uzyskano dla owoców z drzew traktowanych Kalcisalem+Kalcifosem i Sanisalem A (odpowiednio 31 i 35). Spośród analizowanych części owocu najniższe wartości proporcji K/Ca i Mg/Ca uzyskano dla skórki owoców.

Słowa kluczowe: grusza, nawożenie dolistne, skład mineralny owoców, stosunek K/Ca, jakość owoców