Polish J. of Environ. Stud. Vol. 18, No. 4 (2009), 741-744

Letter to Editors

Mineral Composition of 'Conference' Pears as Affected by Different Foliar Sprays

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Received: 7 April 2008
Accepted: 31 March 2009

Abstract

The aim of our two-year study (2004-05) was to assess the effects of different foliar fertilizers (calcium chloride, Kalcisal, Kalcisal+Kalcifos and Sanisal) on fruit mineral content. The paper also presents the distribution of some macronutrients (N, K, Mg and Ca) in different parts of 'Conference' pears. The treatments consisted of five foliar sprays (at the rate of 0.17% Ca) in two week intervals followed by five (at the rate of 0.35% Ca) in one-week intervals. After 120 days of storage, fruits from the treatments were divided into: peel, calyx end, basal end, and outer part of flesh. Each of them was analyzed to assess the contents of nitrogen, potassium, magnesium and calcium.

The mineral content of investigated fruits was strongly affected by fertilizers used as well as by the season. Fruits from non-treated trees contained the lowest amounts of macronutrients (average data of four fruit parts). The higher amounts of potassium, magnesium and calcium was found in 2004. In 2004 the highest concentration of calcium was proved for fruits sprayed with Kalcisal (125.5 mg Ca kg^{-1} f.w.), and in 2005 for calcium chloride (101.3 mg kg^{-1} f.w.). The K/Ca ratio varied from 16 to 35 and 21 to 35 for 2004 and 2005, respectively. As far as K/Ca ratio is concerned, no significant differences between pears sprayed with $CaCl_2$ or Kalcisal in comparison to control was found. On the contrary, in both years of the study, the higher K/Ca ratio for Kalcisal+Kalcifos and Sanisal treatments was noted. Sanisal and Kalcisal+Kalcifos significantly increased N/Ca fruit ratio in 2005, as well as Mg/Ca ratio in all seasons. An analysis of average data for all treatments revealed the highest concentration of investigated macroelements in the peel of fruits. The lowest calcium accumulation was recorded in samples taken near the calyx, and in the outer part of the flesh. The lowest N/Ca, K/Ca and Mg/Ca fruit ratios were investigated for peel, whereas the highest – near the calyx end.

Keywords: mineral nutrition, foliar fertilizers, calcium, pear

Introduction

The mineral equilibrium of fruit is a prerequsite for its health and storability [3]. Many physiological disorders such as cork spot of pears, alfalfa greening of pears, internal breakdown, low temperature breakdown, senescence breakdown, watercore, and superficial scald are associated with low levels of fruit Ca [8]. Calcium has received considerable attention not only for its relationship to physiological disorders, but also for its other beneficial effects in extending the storage life of the fruit, delaying softening and improving internal quality [5, 6, 12]. However, maximizing fruit Ca level is not easily attained either by soil or foliar-application. The efficiency of foliar-applied nutrients

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Table 1. Average pH and contents of P, K, Mg and Ca [mg dm^{-3}] in orchard soils.

		pH_{H_2O}	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

depends on their mobility in the entire plant. The limited translocation of Ca to fruits, as well as a lack of migration from leaves, often makes the foliar application inefficient [1, 7]. Therefore, the objectives of the study were (1) to asses the effects of different preharvest calcium sprays on mineral content of 'Conference' pears (especially in Ca) and (2) to compare a macroelement distribution in different parts of pears as influenced by fertilizers.

Material and Methods

The experiment was conducted in 2004-05 in a pear orchard at the Experimental Station in Garlica Murowana, near Kraków, Poland. The soil of the experimental plot was classified as a brown soil type developed from loess and represents a type described as a silt loam. In the middle of July soil samples were taken for analysis, separately from the herbicide strips (HS), grass strips (GS), and 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 spectroscopy [4] (Table 1).

The plant material was composed of 16-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 (concentrated $CaCl_2$, contains: 11% Ca, 0.1% Mg, 0.02% B),
4. Kalcisal + Kalcifos (concentrated $CaCl_2$, 2% Ca, 18% P, Mg 0.1%, 0.02% B),
5. Sanisal (kaolin clay).

The treatments consisted of five foliar sprays (at the rate of 0.17% Ca) at two-week intervals followed by five (at the rate of 0.35% Ca) at one-week intervals. After 120 days of cold storage fruits from the treatments (20 fruits each) were washed and ten pears were taken for mineral content analyses. Stems and seeds were removed. Fruit flesh was mineralized in a mixture of HNO_3:$HClO_4$:H_2SO_4 (6:2:0.25) and analyzed using atomic absorption spectroscopy (AAS) to assess the content of potassium and calcium. Nitrogen content was assessed only in 2005, according to the Kjeldahl method [4].

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

Results and Discussion

All of the studied foliar fertilizers significantly influenced fruit mineral content. Accumulation of N, Ca and Mg was lower for control pears than for treated ones (Table 2). The only exception was potassium, the difference was not so evident. The highest N concentration was measured for Kalcisal+Kalcifos treatment (1,054 mg kg^{-1} d.w.), while the average value was lower - 802 mg kg^{-1} d.w. Uptake of

Table 2. Mean N, K, Mg and Ca content (mg kg^{-1} f.w.) and of 'Conference' pears as affected by different foliar fertilizers.

Treatment	N	K		Mg		Ca	
	2005	2004	2005	2004	2005	2004	2005
1. Control	589 a	1304 a	1228 a	71.1 a	65.6 a	92.3 a	75.9 a
2. $CaCl_2$	791 bc	1374 a	1317 ab	81.0 b	75.3 b	113.8 b	101.3 c
3. Kalcisal	751 b	1655 b	1258 ab	86.1 bc	72.2 ab	125.5 c	92.8 b
4. Kalcisal+Kalcifos	1054 d	1757 c	1544 c	90.3 c	93.4 c	89.1 a	95.0 b
5. Sanisal	824 c	1800 c	1363 b	90.4 c	77.9 b	91.6 a	91.1 b
Mean for year	802	1578 a	1342 b	83.2	76.9	102.5 a	91.2 b

*Mean separation according to Duncan multiple range test. Numbers followed by the same letter within the same column and the analysis time are not different at α = 0.05. Fruit N measured only in 2005.
†Data are average of four fruit parts.

Table 3. N/Ca, K/Ca and Mg/Ca ratio of 'Conference' pears as influenced by different foliar fertilizers.

Treatment	N/Ca	K/Ca		Mg/Ca	
	2005	2004	2005	2004	2005
1. Control	9 a	21 b	25 ab	1.01 b	1.21 bc
2. $CaCl_2$	10 a	16 a	21 a	0.83 a	1.03 a
3. Kalcisal	11 a	18 ab	21 a	0.84 a	1.09 ab
4. Kalcisal+ Kalcifos	19 c	35 d	35 c	1.49 d	1.70 d
5. Sanisal	13 b	31 c	28 b	1.31 c	1.32 c
Mean for year	13	24	25	1.10	1.27

†Data are average of four fruit parts.

analyzed macronutrients was strongly year-dependent. As stated by some authors [9, 11], growing conditions have a great impact on mineral fruit balance. A higher potassium threshold value was recorded in 2004 (1578 mg kg^{-1} d.w.) as compared to 2005 (1342 mg kg^{-1} d.w.). In 2004, spraying with Kalcisal, Kalcisal+Kalcifos and Sanisal significantly increased K fruit content, while in 2005 this tendency was confirmed only for Kalcisal+Kalcifos. Foliar fertilizers with Mg content significantly increased its level.

The best Ca uptake measured in 2004 was recorded for Kalcisal (125.5 mg kg^{-1} d.w.), lower $CaCl_2$ (113.8 mg kg^{-1} d.w.), while for control fruits it reached only 92.3 mg kg^{-1} d.w. On the contrary, in 2005 the most effective in respect of Ca was spraying with $CaCl_2$ (101.3 mg kg^{-1} d.w.) as compared to control (75.9 mg kg^{-1} d.w). This season Kalcisal, Kalcisal+Kalcifos and Sanisal also significantly increased Ca content (91.4 – 95.0 mg kg^{-1} d.w.). However, no differences among these foliar fertilizers were found. As reported by Tomala and Soska [10], the highest value of Ca fruit content was found for apples sprayed with Kalcisal solutions.

Analyzed nutrient element ratios were also year-dependent (Table 3). In 2005 the higher values of K/Ca and Mg/Ca were observed. In the first year of the experiment, K/Ca ratio varied from 16 ($CaCl_2$) to 35 (Kalcisal+ Kalcifos), in another season the range was 21-35 ($CaCl_2$, Kalcisal and Kalcisal+Klacifos). As far as the N/Ca ratio is concerned, Kalcisal+Kalcifos and Sanisal significantly increased the ratio. It was caused by the highest N concentration for these treatments. Among all investigated treatments the most effective in lowering K/Ca ratio was $CaCl_2$ and Kalcisal.

The specific parts of analyzed fruit greatly influenced mineral content (Table 4). The highest N, Mg and Ca levels were measured for peel. In the case of potassium, lower differences between peel and stem end were noticed. The lowest N content was found in the outer part of flesh (495 mg kg^{-1} d.w.), while stem and calyx end were of medium level (646 and 613 mg kg^{-1} d.w., respectively), followed by peel (1454 mg kg^{-1} d.w.). Both years of the experiment, the lowest K accumulation was recorded for outer part of flesh and calyx end. In the case of Mg, the peel of investigated pears reached twice the amount of other parts. Nevertheless, the biggest differences were found for Ca, peel Ca content was on average 5 times more than other parts. But both years the lowest amount was found in the outer part and calyx end.

Table 4. N, K, Mg and Ca content (mg kg^{-1} f.w.) of 'Conference' pear as affected by different fruit parts.

Part of fruit	N	K		Mg		Ca	
	2005	2004	2005	2004	2005	2004	2005
Peel	1454 c	1869 b	1486 c	145.5 c	130.2 c	252.0 c	238.3 c
Stem end	646 b	1825 b	1605 d	60.5 a	61.8 b	68.3 b	53.1 b
Outer part of flesh	495 a	1344 a	1064 a	59.3 a	49.7 a	48.8 a	35.6 a
Calyx end	613 b	1335 a	1212 b	69.9 b	65.8 b	54.0 a	37.9 a

†Data are average of five treatments.

Table 5. N/Ca, K/Ca and Mg/Ca ratio of 'Conference' pears as influenced by different fruit parts.

Part of fruit	N/Ca	K/Ca		Mg/Ca	
	2005	2004	2005	2004	2005
Peel	6.08 a	7.5 a	6.28 a	0.58 a	0.54 a
Stem end	12.4 d	28.5 b	30.7 b	0.93 b	1.18 b
Outer part of flesh	14.5 c	29.7 b	31.2 b	1.29 c	1.45 c
Calyx end	18.10 d	28.0 b	35.8 c	1.42 d	1.90 d

†Data are average of five treatments.

Some authors [2] reported slightly lower levels of naturally occurring calcium in the calyx half of 'York Imperial' apples than in the stem half, but detected no differences in magnesium between two halves.

All of the studied ratios, N/Ca, K/Ca and Mg/Ca, were the lowest in the peel, whereas the highest were near the calyx end (Table 5). No interaction between studied factors (treatments×part of the fruit) were found.

Conclusions

1. Spraying 'Conference' pears with calcium solutions increases Ca fruit content. The most effective calcium fertilizer was Kalcisal and calcium chloride.
2. The environmental conditions during the vegetation season had a great impact on fertilization efficiency.
3. The highest concentration of N, K, Mg and Ca was noted in the peel of pears. The lowest calcium threshold values were recorded for samples taken near the calyx, and in the outer part of the flesh.

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