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RESPONSE OF LUKASOVKA PEAR TREES TO FOLIAR ZINC SPRAYS

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Abstract

The aim of the study was to examine the efficiency of foliar zinc (Zn) application in pear culture. The experiment was carried out in 2005-2007 in a commercial orchard in central Poland, on 6-8 year-old cv. Lukasovka pear trees, grown on coarse-textured soil, moderately abundant in organic matter or available Zn and slightly acidic in reaction. The trees were sprayed with Zn as EDTA in three periods: (1) before bloom: at the stage of bud break, and green and white bud, at a rate of 80 g Zn ha^{-1} in each spray treatment; (2) after bloom: at petal fall, and 14 and 21 days after full bloom, at a rate of 50 g Zn ha^{-1} per spray or; (3) after harvest, 3-4 weeks before natural leaf fall, at a rate of 200 g Zn ha^{-1}. Trees unsprayed with Zn served as the control. The results showed, that pre-bloom Zn sprays increased status of this micronutrient in flowers, and post-bloom Zn sprays – in leaves and fruits. However, foliar Zn sprays had no effect on tree vigor, set of flowers and fruitlets, yielding, mean fruit weight, fruit russeting, and content of organic acids and soluble solids in fruit flesh. It is concluded that foliar Zn sprays of pear trees with an optimal leaf Zn status (according to the current threshold values) are not successful in improving plant growth, yielding, and fruit quality.

Key words: pear, zinc, foliar sprays.

REAKCJA GRUSZY ODMIANY LUKASÓWKA NA DOKARMIANIE DOLISTNE CYNKIEM

Abstrakt

Celem badań była ocena skuteczności dokarmiania dolistnego cynkiem (Zn) w uprawie gruszy. Doświadczenie przeprowadzono w latach 2005-2007 w prywatnym sadzie w centralnej Polsce. Obiektem doświadczalnym były 6-8-letnie grusze odmiany Lukasówka/pi-

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gwa S1, rosnące na glebie o składzie mechanicznym piasku gliniastego lekkiego, umiarkowanej zawartości materii organicznej, lekko kwaśnym odczynie oraz o średniej zawartości Zn. Grusze opryskiwano Zn w formie EDTA w trzech okresach: (1) przed kwitnieniem: w fazie pękania pąków oraz zielonego i białego pąka, w dawce 80 g Zn ha^{-1} w każdym zabiegu; (2) po kwitnieniu: w fazie opadania płatków kwiatowych oraz 14 i 21 dni później, w dawce 50 g Zn ha^{-1} w każdym zabiegu lub (3) po zbiorze owoców, 3-4 tygodnie przed naturalnym opadaniem liści, w dawce 200 g Zn ha^{-1}. Drzewa nie opryskiwane Zn stanowiły kontrolę. Wykazano, że opryskiwanie Zn przed kwitnieniem zwiększyło zawartość tego mikroskładnika w kwiatach, a opryskiwanie po kwitnieniu – w liściach i owocach. Dokarmianie dolistne Zn nie miało jednak wpływu na wigor drzew, zawiązywanie kwiatów i owoców, plonowanie, średnią masę owocu, ordzawienie owoców oraz zawartość kwasów i ekstraktu w miąższu owoców. Wnioskuje się, że dokarmianie dolistne Zn grusz o optymalnej zawartości tego mikroskładnika w liściach (wg obowiązujących liczb granicznych) nie polepsza wzrostu i plonowania roślin oraz jakości owoców.

Słowa kluczowe: gruszka, cynk, dokarmianie dolistne.

INTRODUCTION

Zinc (Zn) is an essential trace element for plants, as it conditions their good growth and development. It is involved in many enzymatic reactions, regulates the protein and carbohydrate metabolisms, affects integrity of plasmalemma and protects it against excess of O_2 free radicals. It also plays a critical role in cell elongation growth (ŚWIETLIK 1999).

Pear (*Pyrus communis* L.) is considered to be a Zn-sensitive species (SHEAR, FAUST 1980). At low soil Zn availability, plant growth is impaired, and fruit set and tree yielding are limited. Under such conditions, fruits are small, deformed, sour and early ripen. In severe cases, twig tips dry, inducing formation of lateral shoots, which after some time die. Simultaneously, bark of the trunk/branches is rough and cracked (SHEAR, FAUST 1980, ŚWIETLIK 1999, NEILSEN et al. 2005).

In Poland, orchard Zn deficiency signs are rarely observed and most frequently result from overliming; when this happens, it is recommended to spray trees with Zn both before and after bloom (ŚWIETLIK 1999). However, in recent years may fruit tree growers have been applying foliar Zn fertilizers although no tree symptoms of Zn deficiency are observed. Among growers and advisers, opinions about the efficiency of foliar Zn sprays are divided. On the other hand, no comprehensive studies on foliar Zn sprays on fruit crops have been conducted in Poland so far. Thus, it is impossible to decide whether Zn fertilization is necessary. Considering the above arguments, the present experiment has been established to test how efficiently foliar Zn sprays can improve pear tree growth, yielding and fruit quality.

MATERIAL AND METHODS

Localization, plant material and growth conditions

The experiment was conducted in 2005-2007 in a commercial orchard near Grójec. It was carried out on 6-8 year-old cv. Lukasovka pear trees (*Pyrus communis* L.)/quince S1, planted at a spacing of 4 x 2 m (1250 trees per ha), on coarse-textured soil (72% sand, 12% silt, 16% clay) moderately abundant in organic matter (12 g C kg^{-1}). Prior to the study (in autumn 2005), $pH_{(KCl)}$ of the surface soil layer was 6.2, and the levels of available phosphorus (P), potassium (K) and magnesium (Mg) were within the optimal ranges (39 mg P kg^{-1}, 76 mg K kg^{-1}, 32 mg Mg kg^{-1}) proposed by SADOWSKI et al. (1990) for fruit crops. Soil availability of those macronutrients was determined according to the methods recommended in Poland. Soil amount of 1M HCl-extractable Zn (4.8 mg Zn kg^{-1}) was within an optimal range proposed in Poland for agricultural crops.

The experimental trees were trained as a spindle up to a height of 3 m. In tree rows, a 1-m-wide herbicide strips were maintained and in interrows there were stripes of grass sod. From May to August, pears were irrigated (by a drip system) when shortage of water occurred in the surface soil layer (0-30 cm). Annually, pears were supplied with nitrogen and potassium; these nutrients were applied uniformly over the entire orchard soil surface, at the bud break stage, at a rate of 60 kg N ha^{-1} as ammonium nitrate, and of 80 kg K ha^{-1} as potassium chloride. During period of the study, no thinning of flowers/fruitlets was made. The trees were not sprayed with Zn-containing fungicides. Control of pathogens and pests was performed according to the standard recommendations for commercial orchards.

The treatments and experiment layout

Pears were sprayed with Zn as a chelate (EDTA, Chelat Zn 15 top, 15% Zn; Intermag, Olkusz, Poland), in three periods: (1) before bloom: at the stages of bud break, and green and white bud, at a rate of 80 g Zn ha^{-1} in each spray; (2) after bloom: at the petal fall, and 14 and 21 days after full bloom, at a dose of 50 g Zn ha^{-1} per spray or; (3) after harvest, 3-4 weeks before natural leaf fall, at a rate of 200 g Zn ha^{-1}. Sprays of Zn in the first two periods (before and after bloom) were made in 2006 and 2007, whereas in the third period – in 2005 and 2006; in this way it was possible to compare the efficiency of all the spray combinations tested. Different Zn rates in individual pear growth periods were applied so as not to damage of leaves/fruits. Sprays of Zn were made by a hand-held sprayer, using ca. 500 dm^{-3} of water per ha for pre-bloom applications, and ca. 1000 dm^{-3} water for post-bloom and post-harvest treatments. The trees unsprayed with Zn served as the control. Over the three years of the experiment, the same trees were sprayed with Zn in the above variants. The study was conducted using a randomized complete block design with 4 replications. Each experimental plot (replication) consisted of 6 trees.

Measurements and observations

(i) Tree vigor was estimated based on the total length of one-year-old shoots, calculated according to the method of JOLLY, HOLLAND (1958), on two branches from each tree, grown in a row line, at the height of 1.5-2.0 m above ground; (ii) leaf Zn status was determined 95 days after full bloom, on ca 100 leaves per plot. Leaves were taken from the mid-portion of current-season shoots, from the peripherial zone of the canopy, at the height of 1.5--2.0 m above soil surface. Leaves were rinsed with double-deionized water, dried at 75°C, ground in an agate mill, and ashed in a muffle furnace at temperature of 450°C for 12 h. Ash was dissolved in 0.5% HCl, and Zn amount in the solution was determined with an inductively-coupled plasma spectrometer (Thermo Jarrell Ash, Franklin, MA, USA); (iii) flower set was evaluated at the white bud stage, on one branch from each tree, grown in a tree row line, at the height of 1.5-2.0 m above soil surface. The results were expressed as flower number per 1 m of shoot; (iv) flower Zn concentration was determined at the full bloom stage, on 50 flowers (without the stem) per plot, taken from 2 year-old shoots, grown in the peripherial zone of the crown, at the height of 1.5-2.0 m above soil ground. Preparation of flower samples for analysis and determination of Zn were the same as for leaf samples, except that flowers were not rinsed with double-deionized water. Flower Zn concentration was expressed on a dry-mass basis; (v) fruit set was estimated immediately after "Juny drop", on the same branches as flower set. Fruit set was expressed as percentage of set fruitlets in relation to the number of flowers; (vi) fruit yield was weighted from each plot and calculated per ha; (vii) mean fruit weight was calculated on *ca* 20-kg bulk fruit sample per plot; (viii) pear skin russeting was rated on a 20-kg bulk fruit sample per plot, on a scale from 1 (no russeting) to 5 (russeting > 76% of fruit skin surface); (ix) soluble solids concentration and titratable acidity of fruits were measured/determined immediately after harvest (at commercial harvest data), on 40-fruit sample per plot. Soluble solids concentration was measured with an Abbe refractometer, and titratable acidity was determined by titrating the fruit homogenate with 0.1 N NaOH to pH 8.1 (WŁODEK et al. 1958). The results of titratable acidity represent malic acid content expressed as a percentage; (x) fruit Zn concentration was determined after harvest, on 40-fruit sample per plot. Seeds and stems of fruits were removed and two quarter-size pieces were cut out from the opposite sides of each fruit. Further preparation of fruit samples and determination of Zn were the same as the leaf analysis. The results were expressed on a dry--weight basis.

Statistical analysis

All data were subjected to the analysis of variance. Differences between combination means were evaluated separately for each growing season, using Duncan's Multiple Range Test at $P \leq 0.05$. The data of the total length of current season shoots per tree were transformed according to the equation $y = \log(x)$, and of fruit set according to $y = \arcsin(x)$.

RESULTS AND DISSCUSION

Foliar Zn sprays had no effect on pear vigor; the total length of current-season shoots per tree averaged 61.3 m in 2006 and 72.8 m in 2007.

The concentration of Zn in leaves of the control trees was within the optimal range proposed by SADOWSKI et al. 1990 (Table 1). Only post-bloom Zn sprays increased leaf status of this micronutrient (Table 1). Post-bloom Zn sprays were found to produce no effect on tree vigor, hence it can be concluded that pear Zn nutrition in this study was not a factor that limited the vegetative growth.

The flower set, expressed as a number of flowers per 1 m of shoot, did not differ significantly among combinations: 87.3 in 2006 and 112.4 in 2007, on average.

Only pre-bloom Zn sprays enhanced flower Zn status (Table 1). Lack of influence of post-harvest Zn sprays on flower Zn concentration indicates limited mobility of Zn in the plant. Limited movement of Zn^{68} from pear leaves, sprayed with this isotope in the autumn, to woody organs (shoots, branches) and next to developing tissues/organs in the spring was also found by SANCHEZ and RIGHETTI (2002).

Foliar Zn sprays did not affect fruit set, which on average was 7.8% in 2006, and 2.3% in 2007. Low fruit set in 2007 resulted from a spring frost (-5°C), which occurred at the white bud stage. Regardless of this fact, fruit yields among combinations, within each growing season, were comparable (Table 1). This indicates that pear Zn nutrition did not limit the reproductive processes.

The mean fruit weight was not influenced by foliar Zn sprays (Table 1). Fruit skin russeting depended on growing season: in 2006 fruit skin was less damaged than in 2007 (Table 1). Stronger fruit russeting in 2007 probably resulted from flower cell injuries by the spring frost. However, foliar Zn sprays did not affect fruit russeting (Table 1).

The soluble solids concentration and titratable acidity of fruits were not affected by Zn sprays, averaging 14.0% and 0.31% in 2006, and 14.2% and 0.28% in 2007, respectively.

Table 1

Effect of foliar zinc sprays on cv. Lukasovka pear zinc nutrition, yielding, and fruit quality

Treatment	Leaf Zn conc. (mg kg^{-1} d.m.)		Flower Zn conc. (mg kg^{-1} d.m.)		Fruit yield (t ha^{-1})		Mean fruit weight (g)		Fruit russeting (1-5)*		Fruit Zn conc. (mg kg^{-1} d.m.)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Three pre-bloom Zn sprays at a rate of 240 g Zn ha^{-1} $year^{-1}$	32.1*a*	38.7*a*	58.7*b*	63.2*b*	36.7*a*	16.4*a*	280*a*	365*a*	1.5*a*	2.3a	4.1*a*	5.1*a*
Three post-bloom Zn sprays at a rate of 150 g Zn ha^{-1} $year^{-1}$	43.7*b*	48.7*b*	39.7*a*	37.3*a*	32.8*a*	19.2*a*	266*a*	354*a*	1.7*a*	2.5a	10.4*b*	12.4*b*
Post-harvest Zn spray at a rate of 200 g Zn ha^{-1}	33.4*a*	35.2*a*	38.5*a*	38.7*a*	32.4*a*	17.2*a*	276*a*	349*a*	1.1*a*	2.8a	5.3*a*	6.5*a*
No Zn sprays	35.1*a*	36.7*a*	41.7*a*	35.7*a*	35.6*a*	15.7*a*	281*a*	355*a*	1.4*a*	2.7a	4.3*a*	5.4*a*

* the higher value, the stronger fruit skin russeting
Means within the column with the same letter are not significantly different by Duncan's Multiple Range Test at $P \leq 0.05$.

Only fruits of post-bloom Zn-sprayed trees contained more Zn than those of the control trees (Table 1).

CONCLUSIONS

1. Foliar Zn sprays of cv. Lukasovka pear trees/quince S1 with an optimal leaf Zn status (according to the current threshold values) did not affect the tree growth, yielding, and fruit quality.

2. Post-harvest Zn sprays failed to improve pear Zn nutrition in the following season.

3. Pre-bloom Zn sprays increased flower Zn level, and post-bloom Zn sprays – in leaves and fruits.

REFERENCES

JOLLY G.M., HOLLAND D.A. 1958. *Sampling methods for the measurement of extension growth of apple trees*. Annual Report of East Malling Research Station, Kent, UK, 87-90 pp.

NEILSEN G.H., Hogue J.J., NEILSEN D., BOWEN P. 2005. *Postbloom humic- and fulvic-based zinc sprays can improve apple zinc nutrition*. Hort. Sci., 40: 205-208.

SADOWSKI A., NURZYŃSKI J., PACHOLAK E., SMOLARZ K. 1990. *Fertilizer needs of fruit crops.* II. *Rules, threshold values and fertilizer rates*. Instrukcja Upowszechnieniowa nr 3, SGGW, 1-25 (*in Polish*).

SANCHEZ E.E., RIGHETTI T.L. 2002. *Misleading zinc deficiency diagnoses in pome fruit and inappropriate use of foliar zinc sprays*. Acta Hortic., 594: 363-368.

SHEAR C.B., FAUST M. 1980. *Nutritional ranges in deciduous tree fruits and nuts*. Hort. Rev., 2: 142-163.

ŚWIETLIK D. 1999. *Zinc nutrition in horticultural crops*. Hort. Rev., 23: 109–178.

WŁODEK J., LENARTOWICZ W., BYSTYDZIEŃSKA K. 1958. *Potentiometrical determination of fruit acidity*. Pr. Inst. Sad., 3: 197-218 (*in Polish*).