Differential assimilation of nutrients in paclobutrazol-treated peach trees

A. Pequerul, E. Monge, A. Blanco and J. Val

Estación Experimental Aula Dei (CSIC). Apdo. 202. 50080 Zaragoza SPAIN

Abstract

Paclobutrazol (Pbz) is a triazol that effectively inhibits vegetative growth in peach. Changes in mineral element concentration have been generally found. However, uneven distribution of the elements in the soil may partially account for these differences. To ascertain these effects, an experiment was designed under controlled conditions, in which sugar beet, used as a model plant, was grown hidroponically, treated with Pbz and the results compared to those from unbearing peach trees grown in the open. The beets were treated with 1 M Pbz at the first trifoliate stage, and the peach trees with 2 g Pbz/tree shortly AFB. A reduction of 85 % in leaf area and of 70 % in dry weight were recorded in Pbz-treated beet plants, while in Pbz-treated peach these were of 40 % in leaf area and 29 % in dry weight. Nutrient concentration on dry weight basis varied little (about 8 % in beet and 11 % in peach). However, but global assimilation of nutrients on a leaf basis, when compared with controls, decreased up to the same extend as dry weight in beet (70 %) while in peach it was of 25 %. From these results it can be inferred that the mineral fertilization in Pbz-treated peach trees can be reduced to the same extend as the expected reduction in vegetative growth, consequently reducing production costs and environmental contamination.

Key Index Words:

Peach, sugar beet, paclobutrazol, growth regulators, mineral nutrients, leaf urea, dry matter, *Prunus persica* L. Batch, *beta vulgaris*, L

1. Introduction

The requirements of the market for high-quality products are translated, in cultural terms, in the need for producing fruits of high quality fruit at low cost. This induces the fruit grower to introduce cultural practices that permit to obtain that objective. Among these practices, technical personnel highlight, fruit thinning, standard usage of dwarfing rootstocks, pruning and additionally the application of growth regulators, to maintain the size of the tree within some levels that give cause for low cultivation costs.

Paclobutrazol (Pbz) is a triazol that effectively inhibits vegetative growth in peach. Changes in mineral element concentration have been generally found. However, uneven distribution of the elements in the soil may partially account for these differences. To ascertain these effects, an experiment was designed under controlled conditions, in which sugar beet, used as a model plant, was grown hydroponically, treated with Pbz and the results compared to those from peach trees grown in the open.

They have been found discrepancies in sensitivity depending on the different varieties, on the rootstocks on those that are grafted and on the environmental conditions (White, 1987; Davis et al., 1988). It is being observed, furthermore, that the crop load interacts with paclobutrazol varying the inhibition level of growth of the shoots growth provoked by the growth regulator according to the number of fruits carried by the tree. Rieger (1990) working in hydroponics on nNemaguard peach rootstocks, found that Pbz treatment induced decreases in N, P, K, Fe and Mo, whereas levels of Ca, Mg, B and Mn were increased by Pbz. This author stated that the magnitude of changes in foliar nutrition were proportional to the degree of growth suppression. In the case of Fuji apple trees, Huang et al. (1995) found that the that differences in the total DM dry matter accumulated per kg of leaves were negligible. On the other hand, in mango, the leaf content of N, Ca, Mn, Zn and B contents increased by Pbz treatment while P, K and Cu contents decreased (Werner and Schaffer, 1993).

Triazols influence root growth and morphology, therefore they can alter the mineral uptake, that is to say, plant nutrition. Sometimes authors found discordant results among them. This fact can be attributable to the different environmental conditions, plant species or varieties, etc. However, attending the morphological changes suffered by the plants treated with Pbz, and specially those of the leaves (leaf area and thickness), it is obvious that the data are subjected to other multiple sources of variation (intensity of applications, doses, time of application, etc.). Therefore, it is not surprising that authors as Wang et al. (1985) observed that the Pbz-treatments increase the content of N, P, K, C, Mg, B, Zn and Sr in leaves of pear tree. Rieger and Scalabrelli (1990) demonstrated in peach tree, that the foliar concentrations of N, P, K, Fe and Mb decrease slightly, while increase those of C, Mg, B and Mn. On the contrary, results from Wieland and Wample (1985), in apple tree and ours, in peach tree, indicate that the Pbz does not influence the foliar content of N, P, K, and Mg. As it seems, the general trend, in the studied materials, is the lack of variation in the leaf concentration of macroelements when results are expressed in a dry matter basis. In any way, Atkinson (1986), among other, asserts that growth regulators produced greater modifications in the vegetative growth than in fruits. It probably implies increases in demand for certain elements and additional decreases of other. This last assert also coincides with our previous results. In the sense, the only element that increases spectacular and significantly its concentration in peach tree leaves is Mn (Monge, et al., 1993, 1994).

In general, it has been observed that a decrease of the provoked vegetative growth, by dwarfing rootstocks, as well as by the application of growth inhibitors, implies an increase in the productivity. These results indicate that the fruits are organs more powerful than the shoots in the attraction of uptake of water and nutrients. Accordingly, Zhou and Ye (1996) Wright (1989) concluded that the inhibition of the vegetative growth gives cause for increments in the tree productivity of the tree. The dispersion of the nutrients among the different organs depends on the

ability of these organs for the mobilization of the different prosecuting organs that of the sources of compounds that produce production (compounds (Daie, 1985). Paclobutrazol (Pbz) is a triazol that effectively inhibits vegetative growth in peach. Changes in mineral element concentration have been generally found. However, uneven distribution of the elements in the soil may partially account for these differences. To ascertain these effects, an experiment was designed under controlled conditions, in which sugar beet, used as a model plant, was grown hidroponically, treated with Pbz and the results compared to those from peach trees grown in the open.

2. Material and Methods

2.1 Peach trees

The experiment was carried out on a peach tree orchard located in Fuentes de Ebro (ENE Spain) belonging to the ALM group. The orchard consisted on adult trees cv Catherine. The trees were planted on sandy-franco soil with 0.95% organic matter, pH 8.1, being submitted to the normal cultural practices applied in the area, including flooding irrigation. The experiment was performed on homogenous trees being their average trunk girth of 35.32.7 cm. The peach trees were treated with 2 g Pbz/tree shortly AFB, and the leaves were harvested from trees without crop along the summer 1991. In ah cases, the Pbz solutions were prepared by solving the appropriate quantity of the commercial compound (Cultar, ICI) in 1 L of distilled water. The treatment was applied by pouring the solution to the soil around the trunk.

2.2 Sugar beet

Sugar beet plants (*Beta vulgaris* L. Var. Monohili) were ground in hydroponics from commercial seeds. The culture medium consisted on Hoagland's solution in 20 L containers. Pbz treatment was carried out when the plants showed three fully developed leaves, by adding 25 . μ L of Cultar (25% y/y) to the 20 L of nutritive solution. Samples were taken after 30 days of plant development.

2.3 Leaf Area

50 leaves per treatment were measured for their area by an image analyzer (Area Measurement System, AT Devices Ltd., Burwell, Cambridge, England)

2.4 Specific weight

A single disk of known area (1.767 cm²) from 10 leaves per treatment was taken (total area 17.67 cm²). These ten disks were weighted to have the fresh weight and then were dried during 48 h at 60 °C to get the dry weight. The specific weight or leaf index was given by the value of the ratio dry weight/ total area.

2.5 Samples preparation

The leaves were dried in a furnace under hot air at 60 °C during 48 hours. They were grounded and homogenized trough a 60 mesh sieve. 1 g of this material was dry digested in a furnace (600 °C) during 24 h, and the ashes dissolved in nitric acid (1:1). The solution obtained was evaporated until total dryness and the residue was again furnaced for 1 hour at 600 °C. The ashes were dissolved by heating with diluted HCl.

2.6 Analysis of mineral nutrients

K was determined by atomic emission spectroscopy in a Unicam 929. The rest of elements except P were quantified by ICP-AES (Jobin-Yvon. (Mod. JY-38). Nitrogen was determined by Kjeldahl'.

3. Results and Discussion

From Davis et al. (1988) numerous authors agreed about the need for studying how triazols modify plant nutrition: - "their effects in nutrition are of minor relative importance, it is possible that the triazol treatments influence the needs for fertilization" -. Growth regulators are used in agriculture to increase yield or quality of crops through the inhibition of the plant vegetative growth. Also ift

has also been postulated that alter plant metabolism by modifying physiological key process as the nitrogen fixation, outleuptaket of mineral nutrients, senescence and photosynthesis (Gianfagna, 1988).

The parameters describing the leaf morphology of peach trees treated or not with Pbz. Pbz peach leaves suffered a dramatic decrease of their leaf area (40 % for peaches and 84 % for sugar beet). However, these same leaves have to be thinner than those of control attending the decrease in their specific dry weight (18 % for peach and 83 % for sugar beet, respectively). As the number of leaves in Pbz-treated peach trees do not increase, it is obvious that the canopy of the treated trees must be heavily modified. Previous results (Blanco, et al., 1989) also shown that neither the yield nor the number and weight of the fruits are detrimentally affected by the Pbz treatments. Therefore, it seems that the treated trees can perform photosynthesis at a rate high enough as to supply the fruits with their necessary photoasimilates that permit to have a proper development. Assuming that the Pbz-trees carry the same number of leaves than controls, and having into account the reduction in the total foliar dry matter, modifications in the mineral nutrient uptake can be expected.

When leaf mineral contents are exposed in a dry matter basis, global nutrition of the controls trees quantified as the summa of N, P, K, accounts for 4.65 % of the total dry matter, while in Pbz trees the value is 4.38 %. The other macroelements Ca and Mg increased their leaf content per dry weight in the treated trees (27 and 8.7 % respectively), and regarding the micronutrients Fe and Mn increased by a 38 % and Zn and Cu decreased slightly.

However, as stated above the Pbz-treated trees have smaller and thicker leaves, therefore, it could be more accurate the expression of their mineral concentrations as a function of the leaf area. In this case, global nutrition of controls accounts for 295.9 $\mu\text{g cm}^{-2}$, while for treated trees this value increases up to 330.8 $\mu\text{g cm}^{-2}$. The rest of nutrients including Ca, Mg and all micronutrients also increase respect to controls.

It is difficult to elucidate the more convenient way to reflect the nutritional status of plants treated with Pbz. In this way, we propose to express the analytical data as a function of the whole leaf. That is to say the total amount of each nutrient per leaf unit. In this way, taking the single leaf as reservoir of nutrients, K+P+N on Phz-trees was 10.25 mg per leaf and 6.84 on controls. The rest of nutrients also decreased but into a lower extent.

All trees studied were healthy and it seemed that the expression of nutrient concentration in a dry matter basis does not reflect the actual nutritional status of the Pbz-trees. The contents calculated biny this way are not proportional either to the recorder diminution on the leaf area or on the specific leaf dry weight. Similarly, when concentrations are given per leaf area the lack of proportion between leaf area or and dry weight and the nutrient concentrations is evident. Only, when the analytical results are given per single leaf, a good agreement between leaf dry weight per area unit and the amount of nutrients are closely related.

In order to verify these results, another experiment avoiding the variability inherent to the field conditions was performed. Sugar beet was chosen as a model plant, and hydroponics in Hoagland's solution as a nutritive medium. The environmental conditions were controlled in a growth chamber. A similar behaviour than that observed in peach trees could be found in sugar beet. The nutritional difference between both species under different environmental conditions consists on that in the case of sugar beet the changes are dramatic. The results are lot related with the variation in leaf area or in dry weight suffered by the leaves Pbz-treated. A better approach is achieved when nutrient concentrations are expressed in a leaf area basis. However, only if the total amounts of nutrients per whole leaf is amount of nutrients per whole leaf is considered, there is a good agreement between the reduction in both leaf area and dry weight and the nutritional results obtained.

From these results it can be inferred that the mineral fertilization in Pbz-treated peach trees can be reduced to the same extend as the expected reduction in vegetative growth, consequently reducing production costs and environmental contamination.

References

- Atkinson, D. 1986. Effects of some plant regulators on water use and the uptake of mineral nutrients by tree crops. *Acta Hort.* 179: 395-404.
- Blanco, A. 1989. Efectos del paclobutrazol sobre la producción, calidad del fruto y el crecimiento vegetativo en manzanos Reineta Blanca del Canadá. *ITEA.* 83: 3-10.
- Daie, J. 1985. Carbohydrate partitioning and metabolism in crops. *Horticultural Reviews.* 7: 69-108.
- Davis, D., Steffens, G. L. and Sankhla, N. 1988. Triazole plant growth regulators. *Horticultural Reviews.* 10: 63-105.
- Gianfagna, T. J. 1988. Natural and synthetic growth regulators and their use in horticultural and agronomic crops. *Ten: Plant Hormones and Their Role in Plant Growth and Development.* (P. J. Davies, ed.) pp. 614-635. Kluwer Acad. Publ. Dordrecht, The Netherlands
- Huang, W. D., Shen, T., Han, Z. H., and Liu, S. 1995. Influence of paclobutrazol on photosynthesis rate and dry matter partitioning in the apple tree. *Journal-of-Plant Nutrition.* 18: 5, 901-910
- Monge, E., Madero, P., Val, J., and Blanco, A. 1993. Effects of paclobutrazol application and fruit load on microelement concentration in peach leaves. *En: Optimization of Plant Nutrition.* (M. A. C. Frago y M. L. Beusichem. Eds.) pp. 3 19-323. Kluwer Academic Press, Dordrecht, The Netherlands.
- Monge, E., Aguirre, R., and Blanco, A. 1994. Application of paclobutrazol and GA3 to adult peach trees: effects on nutritional status and photosynthetic pigments. *Journal of Plant Growth Regulators.* 13: 15-19.
- Rieger, M. 1990. Paclobutrazol, root growth, hydraulic conductivity, and nutrient uptake of 'Nemaguard' peach. *HortScience.* 25: 1, 95-98
- Rieger, M., and Scalabrelli, G. 1990. Paclobutrazol, root growth, hydraulic conductivity, and nutrient uptake of 'Nemaguard' peach. *HortScience* 25: 95-98.
- Sankhla, N., Davies, T. D., Lolley, V. D. and Upadhyaya, A. 1986. Effect of paclobutrazol on the development of iron chlorosis in soybeans. *J. Plant Nutr.* 9: 923-934.
- Wang, S. Y., Byun, J. K., and Steffens, G. L. 1985. Controlling plant growth via the gibberellin biosynthesis system-II. Biochemical and physiological alterations in apple seedlings. *Physiologia Plantarum.* 63: 169-175.
- Werner, H. and Schaffer, B. 1993. Influence of paclobutrazol on growth and leaf nutrient content of mango (cv. Blanco). *Acta-Horticulturae.* 341: 225-231
- Wieland, W. F. and Wample, R. L. 1985. Root growth, water relations and mineral uptake of young 'Delicious' apples. *Scientia Hort.* 26: 139-147.
- Zhou, W. and Ye, Q. 1996. Physiological and Yield Effects Of Uniconazole On Winter Rape (*Brassica Napus* L.). *Journal of Plant Growth Regulation* 15: 69-73.