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Effect of winter foliar application of urea on some quantitative and qualitative characters of flower and fruit set of orange cv 'Valencia'

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Abstract

Yield of fruit tree is determined primarily by flowering intensity and subsequent fruit set. Flower number and fruit set are also influenced by endogenous nitrogen level. This research was concerned with the effect of winter foliar application of urea on flowering and fruit-set of 30-year-old 'Valencia' orange on sour orange rootstock at Safiabad Agricultural Research Center of Dezful. Treatments included urea foliar application at 3 levels (0, 0.5, 1%) and 2 times of application (6 and 9 weeks before full bloom). The experimental design was a factorial randomize complete block with 4 replications. Nitrogen percentage in leaf, flower number, ovary diameter and fruit set were studied. Results showed that winter application of urea increased the level of N for 2 weeks. Different levels of urea increased the number of flowers, ovary diameter and fruit set. The higher concentration of urea (1%) had more effect. Considering the time of application, urea spray 9 weeks before full bloom had the highest effect on flowering but urea spray 6 weeks before full bloom resulted in higher ovary diameter and fruit set.

Key words: Nitrogen, flowering, fruit set, 'Valencia' Orange

Introduction

Flowering is the most important physiological process in fruit trees. Citrus yield can be closely related to total number of flowers in spring bloom even though most of the flowers don't set fruit that remain until harvest (Moss, 1971). Nitrogen could influence the number of flowers and fruit set (Albrigo, 1999). During flowering and fruit set, high nutrient demand occur and also the soil temperature is low. Low soil temperature reduces root metabolic activity, solubility of nutrients in the soil solution and nutrient transport stream (Lovatt, 1999). During and before flowering, the trees may not be able to translocate sufficient major nutrients (nitrogen, phosphorus, and potassium) for the need of up to 50,000 to 100,000 flowers per tree (Erickson and Brannaman, 1960). Therefore, at low N situation, the pre-blossom urea spray augments the reserve N pool since it is readily accessible and metabolizable (Rabe, 1994).

Researches with citrus have provided evidence of a relationship between ammonium, its metabolites and flowering and fruit set. Leaf concentrations of several C and N compounds before, during and after low temperature or water deficit stress treatments have been quantified in 5-year-old rooted cuttings of 'Washington' navel orange and commercially producing 16-year-old 'Frost Lisbon' lemon trees that were designed to induce flowering (Lovatt *et al.,*1988a; 1988b). Ali and Lovatt (1994) showed mid-January and mid-February application of low biuret urea to 30-year-old 'Washington' navel orange trees, significantly increased yield per tree above the control trees receiving soil applied urea. Mid-January foliar application of low biuret urea significantly increased the number of fruit per tree over the control trees.

It was demonstrated by El-Otmani *et al.*(2004) that urea application to the foliage of 'Cadox' clemantine mandarin trees during the periods of flower initiation-differentiation, fruit set and 'June drop', lead to increased leaf area, leaf specific dry weight, leaf N level and total yield. The yield increase was due to an increase in both, fruit number per tree and fruit size.

The purpose of this study was to evaluate the effect of urea spray (rate and time of application) as a source of nitrogen on flowering and fruit set of 'Valencia' orange.

Materials and methods

Location: The experimental orchard was located in the Safiabad Agricultural Center of Iran, characterized by a subtropical climate with rainfall of 300-400 mm per year with mild winter (10-12°C) and warm summer (35-45°C).

Plant material: Thirty-year-old 'Valencia' orange trees on sour orange rootstock were used. The factorial experiment was arranged in randomize complete block design with 4 replications. Treatments were foliar application of urea in 3 rates (0, 0.5, 1%) and 2 times of application (23 January, 13 February 2006, 9 and 6 week before full bloom, respectively). Urea (46% N) was applied to the foliage to the point of runoff.

Physiological parameters: To determine leaf total N concentration, 30 old spring-cycle leaves from nonfruiting terminals shoots were collected per tree weekly, from 9 weeks before full bloom until 1 week after full bloom. Leaves were washed with 1% HCl and rinsed thoroughly with distilled water and oven dried at 60°C. Total N was determined using micro-kjehldahl method (Ali and Lovatt, 1994).

Flowers and fruits were counted on 10 randomly selected shoots (all sides of the tree), at full bloom and after June drop (10 July), respectively. Percentage of fruit set was calculated by:

Fruit set (%) = (Number of fruits/ Number of flowers) ×100

To determine ovary diameter, before full bloom, 100 flowers were collected from each tree and ovary diameter was measured by digital slide caliper.

Statistical analysis: Data were subjected to an analysis of variance and mean separation was carried out using Duncan's multiple range test at $P<0.01$.

Results and discussion

Leaf nitrogen concentration: From the beginning of experiment on January 23. (first week from the beginning of experiment) until full bloom on March 28 (tenth week from the beginning of experiment) there was a loss of N from the old leaves (Figs.1 and 2).

As most commercial citrus cultivars are evergreen, leaves are the major source of N that support spring and summer growth flushes, since root uptake may not be able to fulfill immediate growth, flowering and fruit set requirement at this time. Citrus leaves, therefore, constitute a major reserve of mobile N (Lea-Cox *et al.*, 2001).

Winter urea sprays markedly increased leaf N level for a short time, second and third weeks from the beginning of experiment (Fig. 1) and fifth and sixth weeks from the beginning of experiment (Fig. 2). This transient increase in the leaf N status has been reported by Rabe (1994). Following application, urea rapidly accumulates in the leaf and transform into amino acids and proteins in order to function as a N source in the citrus trees (Sirvastava and Singh, 2003).

Flower opening (tenth week from the beginning of experiment), period of high nutrient demand (Lovatt, 1999), coincides with

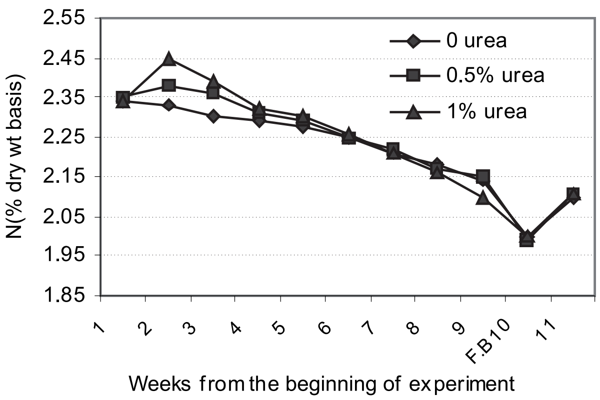

Fig.1. Changes in leaf nitrogen (urea spray: 9 weeks B.F.B)

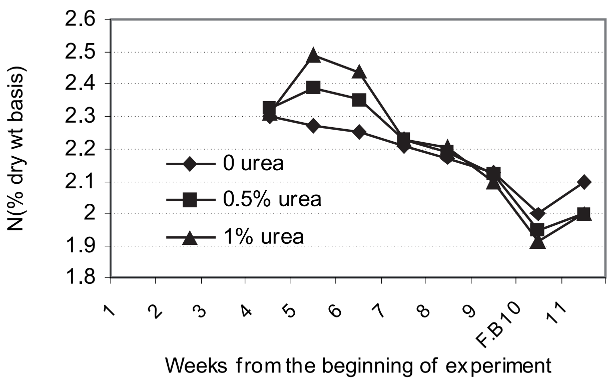

Fig.2. Changes in leaf nitrogen (urea spray: 6 weeks B.F.B)

minimum N values in the leaves (Figs.1and 2). There is a competition for nutrient between flowers, fruitlets and newly developing spring leaves. This agrees with earlier results of Sanz *et al.* (1987) who reported that mineral elements (N, P, K) in old leaves of 'Washington Navel' orange decreased during the spring flush of growth and reached minimum values at flower opening, coinciding with a peak in flower abscission.

Urea spray effect on flowering, fruit set and ovary diameter: Foliar urea spray at 1 and 0.5% concentration significantly ($P<0.01$) affected growth parameters. The greatest number of flower, fruit set and ovary diameter were by 49.2 flower m^{-1} shoot length, 2.32 mm and 2.99%, respectively at 1% urea treatment (Table 1).

Application of urea, 9 weeks before full bloom significantly ($P<0.01$) increased flower number by 24.28% compared to 6 weeks before full bloom (Table 2). But urea spray, 6 weeks before full bloom significantly ($P<0.01$) increased fruit set and ovary diameter by 16.83 and 50% compared to 9 weeks before full bloom (Table 2). The combined effects of urea concentration and time of application treatments are shown in Table 3.

The larger ovary diameter (2.66mm), flower number (57.8 flower m^{-1} shoot length) and fruit set (3.7%) were obtained by urea spray at 1% concentration, 6 and 9 weeks before full bloom, respectively (Table 3).

Moallemi and Dadpour (2004) showed that flower bud differentiation in 'Valencia' orange at Safiabad starts in February. Therefore, urea spray 9 and 6 weeks before full bloom (23 January, 13 February) in this experiment coincide with flower bud induction and differentiation, respectively. In addition to low temperature in the region, which is the most important climatic stress factor inducing citrus flowering, urea application resulted into increased number of flower. Urea spray, 6 weeks before full bloom, at differentiation stage, promotes ovary growth.

Winter foliar fertilizer application increases flowering, fruit set and yield, because essential nutrients for flowering and fruit set are limiting due to reduced transpiration and nutrient acquisition by roots when air and soil temperatures are low (Lovatt,1999). Earlier researches provided evidence that foliar urea applied during or after low temperature or water deficit period increased citrus flowering by elevating the ammonia metabolites status of the tree (Lovatt *et al.,* 1988a, 1988b) and increased the polyamine content, growth rate and size of developing citrus fruit as well as their potential to set (Lovatt *et al.*, 1992).

Following application, urea is transformed into amino acids specially arginine and polyamines (Srivastava and Singh, 2003). Polyamines are involved in many plant developmental processes, including cell division, embryogenesis, reproductive organs development, floral initiation and development and fruit development. They stimulate DNA replication, transcription and translation (Kaur-Sawhney *et al.*, 2003). Evidences indicate a close connection between polyamines and reproductive development in olive (Diose *et al.*, 2006), damson plum (Prista *et al.*, 2004) and *Arabidopsis thaliana* (Applewhite *et al.*, 2000).

Results of our experiment demonstrated that winter application of urea in January or February significantly increased leaf nitrogen status, compared to control trees. Urea spray increased

Table 1. Effect of urea concentration on flowering, ovary diameter and fruit set

Urea concentration (%)	Number of flower (flower m^{-1} shoot length)	Ovary diameter (mm)	Fruit set (%)
0	32.73^{b}	1.92^{b}	1.25^{b}
0.5	43.10^{a}	2.16^{a}	1.99^{b}
1.0	49.20^{a}	2.32^{a}	2.99^{a}

Means within a column with the same letter are not significantly different by Duncan's multiple range test (P<0.01)

Table 2. Effect of time of urea spray on flowering, ovary diameter and fruit set

Time of urea application	Number of flower (flower m^{-1} shoot length)	Ovary diameter (mm)	Fruit set (%)
9 weeks B.F.B.[1]	46.25^{a}	1.96^{b}	1.66^{b}
6 weeks B.F.B.	37.10^{b}	2.29^{a}	2.49^{a}

Means within a column with the same letter are not significantly different by Duncan's multiple range test (P<0.01). Before Full Bloom

Table 3. The combined effects of urea concentration and time of application treatments on flowering, ovary diameter and fruit set.

Parameter	Time of application (weeks B.F.B.)	Urea concentration		
		Control	0.5%	1%
Flower number (flower m^{-1} shoot length)	9 weeks	33.85 ^{cd}	47.10 ^{b}	57.80 ^{a}
	6 weeks	31.36 ^{d}	39.10 ^{c}	40.60 ^{bc}
Ovary diameter (mm)	9 weeks	1.93 ^{c}	2.00 ^{c}	1.98 ^{c}
	6 weeks	1.91 ^{c}	2.32 ^{b}	2.66 ^{a}
Fruit set (%)	9 weeks	1. 32 ^{c}	1.46 ^{c}	2.29 ^{b}
	6 weeks	1.27 ^{c}	2.52 ^{b}	3.70 ^{a}

Means within a column with the same letter are not significantly different by Duncan's multiple range test (P<0.01)

the number of flowers, ovary diameter and fruit set. The highest concentration of urea (1%) had the highest effect. Considering the time of application, urea spray, 9 weeks before full bloom, had the highest effect on flowering but urea spray 6 weeks before full bloom resulted in higher ovary diameter and fruit set. It seems increase in leaf N as a result of urea spray in January or February promotes flower induction (at induction stage) and ovary growth (at differentiation stage), respectively, that lead to increased flowering and fruit set. Therefore, it is important to determine the optimal level and time of application of nutrients to stimulate a specific physiological process in ctrus.

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