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Combining Low Biuret Urea with Foliar Zinc Sulfate Sprays to Fertilize Peach and Nectarine Trees in the Fall

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Abstract

It has been demonstrated that nitrogen (N) applied as foliar urea to peach and nectarine trees in the fall is readily taken up by leaves and distributed throughout the organs of the tree including the roots. Therefore, this method of fertilization could be a useful tool to supplement soil-applied fertilization and thus help reduce the potential for excess nitrates in the environment. Two experiments were conducted to study the horticultural aspects and the practical feasibility of this practice. The first trial consisted of nine combinations of foliar and soil-applied fertilizers imposed in a commercial orchard of 'Queencrest' peach trees over two years. The treatments that included foliar urea to supply part or all of the N fertilizer were equivalent to the soil-fertilized control in fruit soluble solids content, flower density, fruit set and fruit defects. Therefore, there appeared to be no negative horticultural effects of fall foliar urea treatments. The second trial was conducted in a commercial orchard of 'Summer Beaut' nectarine and 'David Sun' peach. The objective of this experiment was to study the feasibility of combining foliar urea with zinc sulfate sprays that are co only applied commercially to California stone fruit orchards in October. Eight different combinations were tested. Foliar urea substantially increased leaf N concentration the day after application. However, the amount of N that moved out of the leaves before leaf senescence was the same as the unsprayed control. When urea was combined with zinc sulfate, there was a significantly greater decrease in leaf N suggesting zinc helps mobilize N out of the leaves. Zinc sulfate caused earlier defoliation compared to the unsprayed control and the addition of urea advanced it further by about a week in one of two years. However, none of the combinations caused any reduction in flowering compared to the unsprayed control.

INTRODUCTION

Nitrogen is a critical nutrient in stone fruit orchards that generally must be applied annually to ensure continued productivity. This element must be applied as efficiently as possible to prevent environmental contamination of the groundwater or other aquifers. The build-up of N in the environment is an ongoing problem throughout the world. Methods and approaches to improving N fertilizer use efficiency are the goal of many research programs. One approach is the use of foliar urea sprays so that soil-applied fertilizers can be eliminated or reduced. Recent research has demonstrated that N is taken up very efficiently by peach leaves when high rates of foliar urea are applied in the fall (Rosecrance et al., 1998a).

Furthermore, this N is redistributed throughout the tree, including the roots, and becomes available for fruit and shoot growth the following spring (Rosecrance et al., 1998b; Tagliavini et al., 1998). When half the tree N needs is supplied in this way (and soil-applied N is cut in half) there is no loss of productivity or fruit growth (Johnson et al., 2001). This project was initiated to test the effect of fall foliar urea sprays on fruit quality of 'Queencrest' peach and also to test the feasibility of combining urea with fall zinc sulfate sprays that are commonly applied to peach orchards in California.

MATERIALS AND METHODS

Experiment 1

This study was conducted in a commercial 2.3-ha block of mature 'Queencrest' peach on 'Nemaguard' rootstock near Parlier, California, USA. Trees were planted on a 4.9x5.5-m spacing and trained to an open vase. The orchard was furrow-irrigated and standard pest management and other cultural practices were employed. Six replications of nine treatments were imposed beginning in the fall of 1992. Each of these 54 plots consisted of two adjacent trees with a border tree on either end and border rows on either side. The treatments were designed to impose different timings, rates and formulations of low biuret urea. The nine treatments were as follows: (1) unfertilized control, (2) 168 kg/ha of soil applied N, half in the early fall and half in spring, (3) 84 kg/ha of soil applied N, half in the early fall and half in spring (N source for Treatments 2 and 3 was ammonium nitrate), (4) 112 kg/ha of foliar applied N using 2 equal applications of a liquid formulation of low biuret urea sprayed 2 weeks apart in October, (5) same as Treatment 4 using a granular formulation of low biuret urea, (6) 84 kg/ha of foliar applied N using a single spray of liquid low biuret urea in early October, (7) same as Treatment 6 but applied at the end of October, (8) 84 kg/ha of foliar applied N using 3 equal applications of liquid low biuret urea sprayed:2 weeks apart starting in early October, and (9) 84 kg/ha of foliar applied N using 5 sprays of liquid low biuret urea, two 28 kg/ha sprays in October and three 9 kg/ha sprays in the spring. All foliar applications were made with a commercial airblast sprayer at a rate of 2500 L/ha.

The experiment was carried out through bloom in March 1994. Flowering, fruit set and double fruit determinations were made by tagging 10 fruiting shoots per plot in both 1993 and 1994. At bloom, measurements of shoot length and number of flowers were taken. About one month later the number of fruits and double fruits were recorded so flower density, % fruit set and % double fruits could be calculated. In 1993, at each of the 2 commercial harvests (early May), 20 fruit samples per plot were collected and analyzed for cheek and tip firmness using a series L mechanical force gauge (Ametek, Paoli, Pennsylvania, USA). Single slices from each of the 20 fruits were then combined to obtain a composite soluble solids content measurement using a model 10430 temperature compensating hand refractometer (American Optical, Buffalo, New York, USA). Standard analysis of variance using CoHort software was run on each variable and mean separations determined by Duncan's Multiple Range Test (P=0.05).

Experiment 2

A 4.5-ha commercial high-density 'Summer Beaut' nectarine orchard on 'Nemaguard' rootstock planted 1.1x3.4 m and trained to a central leader was selected for this study. A randomized complete block design was utilized with six replications of eight treatments. Each plot contained three adjacent rows of 61 trees per row. The treatments were as follows: (1) unfertilized control, (2) 112 kg/ha of soil-applied N split equally between fall and spring, (3) 112 kg/ha of foliar-applied N using a single spray of urea applied in October, and (4) 56 kg/ha of soil-applied N in the spring and 56 kg/ha of foliar-applied N using a urea spray in October. Treatments 5-8 corresponded to Treatments 1-4 with the addition of an October zinc spray. Calcium ammonium nitrate solution (17% N) was used for all soil applications and a liquid formulation of urea with less than .025% biuret was used for all foliar applications. Zinc was applied as zinc sulfate (36% Zn) at a rate of 13 kg/ha The urea and zinc sprays were combined in the orchard airblast sprayer and applied at a rate of 800 L/ha solution.

The experiment was initiated in the fall of 1994 with soil treatments applied on 21 September and foliar treatments applied 11 October. Due to a misunderstanding, the orchard was removed in December 1994. The same treatments were then applied to a similar orchard of 'David Sun' peach in 1995. Application dates were 2 May and 8 September for soil treatments and 24 October for foliar sprays. The experiment was terminated after bloom in 1996.

Leaf N was evaluated in 1994 by collecting samples of 40-60 leaves per plot on 6 July, 10 October (day before foliar sprays), 12 October (day after foliar sprays), 19 October and 27 October. On the last sampling date both green leaves and yellow leaves were sampled separately. Yellow leaves detached easily with a gentle pull suggesting they were ready to abscise. Samples were washed, dried at 65°C, ground and sent to the UC analytical lab for analysis of total Kjeldahl N. After the foliar applications in both 1994 and 1995, weekly observations of defoliation in each plot were made individually by the 2 authors and their scores averaged together. Flower density measurements and statistical analysis were conducted similarly to Experiment I.

RESULTS AND DISCUSSION

In general, the various foliar urea rates, timings, and formulations of Experiment 1 showed no adverse effects on flowering or fruit quality (Tables 1 and 2). Only one treatment showed a slight reduction in flower density that was 79% of the control in one of two years of the experiment (Table 1). This treatment (Treatment 5) used a different formulation of urea than the other treatments, suggesting there could be a slight phytotoxic effect of the formulation. This granular formulation had a biuret content guaranteed to be below 0.25%, while the liquid material used for the other treatments was guaranteed to be below 0.05% biuret content. Although both of these concentrations are very low, the granular formulation may have had 5 times more biuret. No independent analyses were done on the materials so this is merely speculation but for future research it would be worthwhile to evaluate how sensitive peach flower buds are to biuret.

It also should be noted that even though Treatment 5 reduced flower density, it showed significantly increased fruit set compared to the control in the same year (Table 1). One possible explanation here is that the foliar urea treatment was most phytotoxic to weaker flower buds leaving those flower buds with a greater chance of setting fruit. Therefore, the potentially negative effect of reduced flowering was at least partially compensated for by better fruit set and maybe even better quality flowers. Actually, since most peach cultivars need to be hand-thinned, a small reduction in flower density would generally be considered a positive effect, especially if it decreased the time needed for hand thinning.

Fruit quality measured at harvest in 1993 also showed no negative effects of the various foliar urea treatments (Table 2). There were significant differences in tip firmness of the fruit in the first harvest, but the differences were mainly due to the unfertilized control having a softer tip than most of the other treatments. Since the soil-fertilized treatments (Treatments 2 and 3) also had greater tip firmness, this must be considered a N effect and not a benefit derived from using foliar urea.

The overall conclusion from Experiment 1 is that foliar urea used at different times in the fall, and with different rates and formulations, is not harmful to the productivity and fruit quality of peach trees.

In Experiment 2, the foliar urea treatments applied on 11 October substantially increased leaf N levels the day after treatment (Table 3). These levels then dropped off during the next 2 weeks suggesting N was being mobilized out of the leaf and into the permanent structures of the tree. By the time leaves were senescing on 27 October, leaf N had decreased substantially. The control and soil fertilized treatments (Treatments 1 and 2) had lost about half of their N as has been reported from other studies (Castagnoli et al., 1990; Taylor and van den Ende, 1969). This was equivalent to about 10 or 11 mg/g N that was remobilized into the tree. The two foliar urea treatments (Treatments 3 and 4) also showed decreased leaf N but only the same absolute amount as the control. In other words, even though foliar urea was able to substantially increase leaf N content, it was apparently not able to increase the total amount of N moving into the permanent structures of the tree. However, when combined with zinc sulfate, much more N was remobilized. Treatment 7 had a N concentration of 40.5 mg/g the day after application which dropped to 22.9 mg/g in senescing leaves for a difference of 17.6 mg/g. This compares to 11.9 mg/g for the urea alone spray (Treatment 3) and 9.8 mg/g for the unfertilized control. Urea has been shown to enhance the uptake of other elements into leaves (El-Fouly et al., 1990), so perhaps there is a synergistic relationship between urea and zinc where each helps in the uptake and mobilization of the other. Future research should focus on elucidating this relationship so it can be exploited in field applications.

Zinc sulfate has been shown to advance defoliation in fruit trees (Castagnoli et al., 1990), Foliar urea also can have the same effect. In Experiment 2, the rate of defoliation by these two materials and their interaction with each other was quite different in the two years of the study (Tables 4 and 5). In 1994, the urea treatment at both rates (Treatments 3 and 4) advanced leaf fall over the control by one to two weeks. The zinc treatments only advanced it by less than a week. The combination of the two materials together was essentially the same as urea alone (Table 4). In 1995, zinc sprays showed the greater effect by advancing defoliation two to three weeks compared to the control. The high rate of urea with or without zinc showed about the same pattern as the zinc alone. However, the low rate of urea only advanced defoliation by one to two weeks compared to the control and, when combined with zinc, the results were generally an average of the two materials alone (Table 5). None of the treatments caused a reduction in flowering in the following year (Table 5).

In conclusion, the combination of urea and zinc sulfate in a single spray causes no damage to the tree in the form of rapid defoliation, shoot dieback or reduced flowering. In fact some benefits may be derived from this combination in the form of greater mobility of N into the permanent structures of the tree.

In summary, applying foliar urea in the fall to peach trees is an effective method of N fertilization that causes no damage to the tree or to flower buds for the following year's crop. When combined with standard zinc sulfate sprays, it could fit easily into a grower's established cultural practices and become an inexpensive and efficient means of supplementing soil N fertilization.

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Tables

Table 1. Flowering, fruit set and double fruit formation of 'Queencrest' peach as affected by different soil-applied and foliar nitrogen treatments. See Materials and Methods, Experiment 1, for details of treatments.

	Flower Density (no.cm)		Fruit Set (no. frt/no. flowers)		Double Fruit %	
Treatment	1993	1994	1993	1994	1993	1994
1. Unfertilized Control	.48a	.47	.88 bc	.82	30	2
2. Soil N – 168 kg/ha	.48a	.41	.93 ab	.86	30	5
3. Soil N – 84 kg/ha	.48a	.50	.89 bc	.84	28	5
4. Foliar N – 2X 56 kg/ha	.45a	.49	.91 abc	.79	30	5
5. Trt. 4 – Granular Urea	.38b	.45	.95 a	.79	26	3
6. Foliar N – 1x 84 kg/ha	.49a	.51	.86 c	.77	32	3
7. Trt. 6 – Later Spray	.46a	.44	.90 abc	.84	26	2
8. Foliar N – 3x28 kg/ha	.50a	.51	.91 ab	.82	28	2
9. Foliar N – Fall & Spring	.44a	.48	.92 ab	.84	35	5

[z]Mean separation within columns by Duncan's Multiple Range Test ($P = 0.05$). No letters in columns indicates no significant differences.

Table 2. Fruit quality parameters at harvest of 'Queencrest' peach as affected by different soil-applied and foliar nitrogen treatments. See Materials and Methods, Experiment 1, for details of treatments.

	SSC (°Brix)		Check Firmness (N)		Tip Firmness (N)	
Treatment	Harvest 1	Harvest 2	Harvest 1	Harvest 2	Harvest 1	Harvest 2
1. Unfertilized Control	11.2	11.5	47.2	48.5	29.1c[z]	29.1
2. Soil N – 168 kg/ha	11.6	11.6	49.0	48.5	34.4 ab	29.5
3. Soil N – 84 kg/ha	11.3	10.9	49.8	47.6	35.7 ab	33.1
4. Foliar N – 2X 56 kg/ha	11.6	11.1	47.2	46.7	31.3 bc	30.9
5. Trt. 4 – Granular Urea	11.4	10.9	48.5	46.3	35.3 ab	31.3
6. Foliar N – 1x 84	11.6	10.9	49.4	48.1	34.8 ab	32.2
7. Trt. 6 – Later Spray	11.4	10.9	49.8	46.7	36.6 a	30.4
8. Foliar N – 3x28 kg/ha	11.3	11.4	50.7	48.1	38.4 a	35.3
9. Foliar N – Fall & Spring	11.0	10.8	52.0	49.8	39.2 a	32.6

[z]Mean separation within col s by Duncan s Multiple Range Test ($P = 0.05$). No letters in columns indicates no significant differences.

Table 3. Leaf nitrogen concentration of 'Summer Beaut' nectarine in 1994 as affected by different soil-applied and foliar nitrogen treatments. Foliar urea and zinc sulfate treatments were applied on 11 October. See Materials and Methods, Experiment 2, for other details of treatments.

	Leaf N (mg/g)						
Treatment	6 Jul	10 Oct	12 Oct	19 Oct	27 Oct green	27 Oct yellow	12 Oct to 27 Oct. change
1. Unfertilized Control	28.8	23.4	22.2 d	22.8 d	21.8 cd	12.4 e	9.8 bcd
2. Soil N – 112 kg/ha	28.9	24.0	23.7 d	22.3 d	23.3 c	12.3 e	11.4 bc
3. Foliar N – 112 kg/ha	28.8	21.2	36.9 b	33.7 a	33.3 a	25.0 a	11.9 bc
4. Soil/Foliar N – 56/56 kg/ha	28.8	21.9	30.1 c	29.1 b	27.0 b	19.2 c	10.9 bcd
5. Foliar Zn	28.8	23.9	22.0 d	21.1 d	20.0 d	13.6 e	8.4 cd
6. Trt. 2 + Foliar Zn	28.8	23.2	22.8 d	22.5 d	22.0 cd	15.3 d	7.5 d
7. Trt. 3 + Foliar Zn	29.1	22.5	40.5 a	33.3 a	31.7 a	22.9 b	17.6 a
8. Trt. 4 + Foliar Zn	29.1	22.1	31.2 c	25.6 c	26.4 b	17.7 c	13.5 b

[z]Mean separation within columns by Duncan's Multiple Range Test ($P = 0.05$). No letters in columns indicates no significant differences

Table 4. Percent defoliation of 'Summer Beaut' nectarine trees in 1994 as affected by different nitrogen and zinc treatments. Foliar urea and zinc sulfate treatments were applied on 11 October. See Materials and Methods, Experiment 2, for other details of treatments

	% Defoliation					
Treatment	18 Oct	25 Oct	1 Nov	8 Nov	15 Nov	22 Nov
1. Unfertilized Control	5 bc[z]	8 d	43 d	73 c	87 bc	98 b
2. Soil N – 112 kg/ha	2 d	9 d	26 e	53 d	76 d	98 b
3. Foliar N – 112 kg/ha	6 b	64 a	85 a	94 a	95 a	98 b
4. Soil/Foliar N – 56/56 kg/ha	4 bcd	35 bc	72 b	81 b	84 c	98 b
5. Foliar Zn	3 cd	20 cd	57 c	78 bc	93 ab	100 a
6. Trt. 2 + Foliar Zn	3 cd	13 d	36 d	73 c	87 bc	100 a
7. Trt. 3 + Foliar Zn	13 a	66 a	89 a	95 a	96 a	99 b
8. Trt. 4 + Foliar Zn	6 b	46 b	70 b	80 bc	84 c	98 b

Mean separation within columns by Duncan's Multiple Range Test (P = 0.05).

Table 5. Percent defoliation in 1995 and flower density in 1996 of 'David Sun' peach as affected by different nitrogen and zinc treatments. Foliar urea and zinc sulfate treatments were applied on 24 October. See Materials and Methods, Experiment 2, for other details of treatments

Treatment	% Defoliation						Flower Density
	3 Nov	10 Nov	17 Nov	22 Nov	1 Dec	8 Dec	(no./cm)
1. Unfertilized Control	1 d	4 e	16 d	24 d	58 e	96 d	.46
2. Soil N – 112 kg/ha	1 d	4 e	15 d	26 d	63 d	96 d	.45
3. Foliar N – 112 kg/ha	9 b	47 b	84 a	88 a	98 a	99 a	.37
4. Soil/Foliar N – 56/56 kg/ha	5 c	18 d	60 c	67 c	90 c	98 bc	.46
5. Foliar Zn	13 a	63 a	83 a	86 ab	94 abc	98 bc	.44
6. Trt. 2 + Foliar Zn	13 a	65 a	88 a	87 ab	94 abc	99 a	.45
7. Trt. 3 + Foliar Zn	16 a	60 a	88 a	90 a	96 ab	99 a	.39
8. Trt. 4+ Foliar Zn	8 bc	37 c	72 b	78 b	92 bc	97 c	.39

[z]Mean separation within columns by Duncan's Multiple Range Test (P = 0.05). No letters in columns indicates no significant differences