Proc. Fla. State Hort. Soc. 120:64–66. 2007.

Effect of Winter- and Springtime Applications of Foliar Urea, NPK, or K-phosphite Sprays on Productivity of Citrus in Central Florida

L. Gene Albrigo*

University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

Additional index words. 'Valencia', 'Hamlin', 'Flame', grapefruit, orange, yield

Previous work in South Florida indicated that wintertime, bloom and postbloom foliar nutritional sprays of urea, K-phosphite, or NPK mixes resulted in increased yields of citrus on poorer-yielding flatwood soils. Whether similar sprays could enhance yields of better-performing Central Florida groves was addressed by tests for up to four consecutive years on the same trees that also all received standard soil-applied fertilizer. Wintertime urea sprays and bloom and/or postbloom NPK mixes in all combinations were applied to navel, 'Hamlin', or 'Valencia' oranges, or 'Flame' grapefruit. N rates from urea ranged from 8 to 16 lbs acre/spray with either 4 or 8 lbs of P and K. In the NPK tests, no consistent differences in yield were found and in seven of 16 cases, treatments that included winter urea were near the lowest yields. When all years were combined, the nonsprayed controls usually were equal to other treatments except for the 'Flame' grapefruit test. For P tests, K-phosphite or urea were sprayed during the winter and NK with or without PO_4 or PO_3 were sprayed at bloom and/or postbloom on 'Hamlin' and 'Valencia' trees in several locations in Central Florida. In these tests, 0, 2.4, or 8 lb of P were used with 16 lb N as urea and 8 or 9.8 lb of K. Again, there were no consistent treatment effects on yields. Overall, no consistent pattern emerged to suggest that foliar sprays of various combinations of foliar-applied NPK solutions using up to 44 or 60 lb additional N/acre increased yields on citrus blocks that were producing well using standard ground-applied fertilizer programs.

Sanz et al. (1987) demonstrated that mature leaf N, P, and K decreased significantly during bloom as new leaf and fruit growth had a strong requirement for these nutrients. Previous work in South Florida indicated that wintertime (Albrigo, 1999), bloom time, and postbloom nutritional sprays of urea, K-phosphite (PO_3) or NPK mixes resulted in increased yields of citrus on poorer yielding flatwood soils (Albrigo, 2002). Besides the apparent extra need at this time demonstrated by Sanz et al. (1987), another reason for the success of these treatments may have been that foliar applications substituted for poor root health and little uptake of soil nutrients. Whether similar nutritional sprays could enhance yields of better-performing Central Florida groves was addressed by testing various nutritional combinations (timing x materials) for up to four consecutive years on the same trees in groves receiving standard soil-applied fertilizer programs. It was hypothesized that winter and spring foliar sprays of major elements would not increase yield on deep well-drained soils where root health allowed efficient uptake of soil-applied fertilizer. Further, it was hypothesized that inclusion of P in spring foliar nutrition sprays would not increase yields on well-drained soils since P is accumulated in small quantities in citrus trees compared to N and K and foliar supplements on Florida soils are usually not needed.

Materials and Methods

In NPK tests, winter urea, and bloom and/or postbloom NPK mixes in all combinations were applied to navel, 'Hamlin', or 'Valencia' oranges, or 'Flame' grapefruit in locations near Auburndale, Avon Park, or Sebring, FL (sites), in deep, well-drained soils. For P tests, K-phosphite or urea were sprayed during the winter and NK with or without PO_4 or PO_3 were sprayed at bloom and/or postbloom on 'Hamlin' trees near Auburndale, and 'Valencia' trees near Avon Park or Sebring, in Central Florida, all on well-drained soils. All sites had four replicates of six tree plots for each treatment applied annually for four consecutive years. Test trees were on various rootstocks, record trees appeared healthy, and all groves received standard ground fertilizer programs based on 180 to 220 lb N/acre.

For NPK treatments using wintertime urea, the N rate was 28 lb/acre applied in early January. In the spring, 8 or 16 lb N as urea with P and K at either 4 or 8 lb/acre, respectively (at 2–1–1 ratios), were applied to designated plots over the four study seasons from 2002–03 until 2005–06 (Table 1). At the same or other sites, combinations of winter urea or PO_3, bloom and postbloom NK or NPK sprays using PO_3 were applied foliarly (Table 1). In these tests, winter sprays had urea N of 28 lb/acre or K PO_3 (26% P) at 2.5 qt/acre. Springtime or postbloom applications consisted of 16 lb N as urea/acre with rates of 0, 2.4, or 8 lb of P (8 lb rate for PO_4 only) and 8 or 9.8 lb of K (9.8 rate with PO_3 only) or at 2–0–1, 2–1–1, or 2–1–1.2 ratios if PO_3 was applied. Flowering, fruit set and yields were monitored, but only yields are reported here. At the Sebring 'Valencia' site, yields were obtained for only the last 2 years.

Differences in yield for the treatments at each site were determined by analysis of variance and if significant differences existed, a Duncan multiple range test was performed to determine which treatments were different. All treatment differences at the 5% probability level were denoted with lower case letters and

*Corresponding author; email: albrigo@ufl.edu; phone: (863) 956-1151, ext. 1207.

Table 1. Treatments of various NPK foliar sprays (four sites) or P tests (three sites) indicating the time of application (winter, W; bloom, B; postbloom, PB) and the materials (urea, U) and amounts used in pounds per acre.

Treatment	NPK tests			P tests		
no.	Time of applications	Materials	Rates	Time of applications	Materials	Rates
1	none	none	none	none	none	none
2	W	U	28 lb/acre	W	U	28 lb/acre
3	W + B + Pb	U + NPK_1	28 + 8–4–4	W	PO_3	2.5 qt/acre
4	W + B + Pb	U + NPK_2	28+ 16–8–8	W + B	U + NK_2	28 lb + 16–8
5	B	NPK_1	8–4–4	W + B	U + NPK_2	" + 16–8–8
6	Pb	NPK_1	8–4–4	W + B	U + NPK_2 (PO_3)	" + 16–2–9.8
7	B	NPK_2	16–8–8	W + B	PO_3 + NPK_2 (PO_3)	2 + 16–2–9.8
8	Pb	NPK_2	16–8–8	W + Pb	U + NK	28 lb + 16–0–8
9	B + Pb	NPK_1	8–4–4	W + Pb	U + NPK	" + 16–8–8
10	B + Pb	NPK_2	16–8–8	W + Pb	PO_3 + NPK_2 (PO_3)	2 + 16–2–9.8

Table 2. Yield in boxes per tree for large 'Hamlin' (H) orange trees near Auburndale, FL; large 'Valencia' (V) orange trees near Avon Park, FL; medium navel orange trees near Sebring, FL; and large 'Flame' (F) grapefruit trees near Sebring, for treatments of winter urea (WU) and/or NPK applications at bloom (B) or postbloom (PB).

Location	Control	WU	WU NPK_1 B PB	WU NPK_2 B + PB	NPK_1 B	NPK_1 PB	NPK_2 B	NPK_2 PB	NPK_1 B + PB	NPK_2 B + PB
Auburndale (H)	6.5 a	6.2 ab	6.6 a	5.5 ab	5.6 ab	6.1 ab	5.4 ab	5.9 ab	5.3 b	5.8 ab
Avon Park (V)	4.2 abc	4.1 abc	3.9 abc	4.3 ab	3.7 bc	3.9 abc	4.6 a	3.5 c	4.1 abc	4.1 abc
Sebring (navel)	5.2 ab	5.5 ab	5.0 ab	5.2 ab	5.8 a	4.8 b	5.0 ab	5.3 ab	5.1 ab	5.3 ab
Sebring (F)	4.6 bcd	4.6 bcd	4.6 bcd	5.4 a	4.3 cd	4.8 abc	4.9 abc	4.0 d	5.3 ab	4.6 bcd

Table 3. Average yield by year in boxes per tree for large 'Hamlin' (H) orange trees near Auburndale, FL; large 'Valencia' (V) orange trees near Avon Park, FL; medium navel orange trees near Sebring, FL; and large 'Flame' (F) grapefruit trees near Sebring, for all plots of winter urea and/or NPK applications at bloom or postbloom.

Location	2002–03	2003–04	2004–05	2005–06
Auburndale (H)	4.7 C	8.5 A	3.9 D	6.5 B
Avon Park (V)	4.7 A	4.5 A	3.4 B	3.4 B
Sebring (navel)	6.7 B	7.5 A	2.7 D	4.0 C
Sebring (F)	5.8 A	5.5 A	3.8 B	3.7 B

all between-year differences at the 1% probability level were denoted with upper case letters.

Results and Discussion

In the NPK tests, no significant differences were found in half (eight of 16) of the comparisons (years × sites, data not shown). In five tests (years × sites), the nonsprayed controls without foliar N, P, or K, had higher yields than when N or NPK applications were made in winter or at bloom or postbloom. In seven cases, treatments that included winter urea were near the lowest yields.

When all years were combined (Table 2), significant differences occurred at all four test sites, but the controls were equal to other treatments at all sites except the Sebring 'Flame' grapefruit test, where winter urea with the highest rate of NPK applied at bloom and postbloom had the highest yield. Although these significant differences occurred, no consistent pattern was discerned to suggest that foliar sprays of NPK solutions increased yields on blocks that were producing well using standard ground-applied fertilizer programs.

There were considerable differences in year-to-year yield at all sites with the 2004–05 season, a year of multiple hurricanes, producing the lowest yields, whereas the previous year was either the highest or one of the highest-yielding years (Table 3).

For the P tests, six of 10 comparisons (sites × years) had no sigificant differences in yield (data not shown). At one site, the control was highest, and in another test it was significantly lower than any other treatment (Table 4). For all years combined by location, only the Sebring 'Valencia' test had any significant difference in yields (Table 4). In this case, the controls had the highest yield and only the winter PO_3 with NPK_2 using PO_3 had lower yields.

Table 4. Yield in boxes per tree for large 'Hamlin' (H) orange trees near Auburndale, FL; medium 'Valencia' (V) orange trees near Avon Park, FL; and large 'Valencia' orange trees near Sebring, FL, for treatments of winter urea (WU) or phosphorous acid (PO_3) and/or NK or P applications at bloom (B) or postbloom (PB).

Location	Control	WU	W PO_3	WU NK B	WU NPK_2 B	WU NPK_2 PO_3 B	W PO_3 NPK_2 PO_3 B	WU NK PB	WU NPK PB	W PO_3 NPK_2 PO_3 PB
Auburndale (H)	5.6 a	5.8 a	5.8 a	5.0 a	5.4 a	6.1 a	5.6 a	5.7 a	6.1 a	6.1 a
Avon Park (V)	3.9 a	4.1 a	4.6 a	4.1 a	3.9 a	4.6 a	4.4 a	4.3 a	3.9 a	4.1 a
Sebring (V)	5.6 a	5.0 ab	5.3 ab	5.0 ab	5.0 ab	5.4 ab	4.5 b	5.0 ab	4.9 ab	4.8 ab

Table 5. Average yield by year in boxes per tree for large 'Hamlin' (H) orange trees near Auburndale, FL; medium 'Valencia' (V) orange trees near Avon Park, FL; and large 'Valencia' trees near Sebring, FL, for all plots of winter urea or phosphorous acid and/or NK applications at bloom or postbloom.

Location	2002–03	2003–04	2004–05	2005–06
Auburndale (H)	5.8 B	7.1 A	4.4 C	5.6 B
Avon Park (V)	5.5 A	4.5 B	3.7 C	3.1 D
Sebring (V)	---	---	3.8 B	6.3 A

As in the NPK tests, the 2004–05 yields were usually lowest or nearly so, whereas the earlier years were higher (Table 5). There weren't any obvious significant yield differences across treatments, on a yearly basis (data not shown), to suggest the low yield years prevented some spray treatments from performing better. Across years and sites, yields were not consistently better for any given treatment.

Since there were no consistent treatment responses for either test set at any location or between locations, it appears that the previous South Florida responses (Albrigo, 1999, 2002) may have been due to foliar sprays serving as an alternative to root uptake of nutrients where presumed poor root health existed on shallow flatwood soils. In this current report, no obvious responses occurred where yields were already relatively good using standard soil-applied fertilizer programs. The average yields in 90 lb (40 kg) boxes/acre for the controls at the six locations were: Auburndale 'Hamlin', 702; Avon Park older 'Valencia', 487; Sebring 'navel', 717; Sebring 'Flame grapefruit, 525; Avon Park young 'Valencia', 531; and Sebring older 'Valencia', 648 boxes/acre.

Since the nonsprayed controls usually had the highest, or near highest yields, and the yield differences were not consistent across NPK or PO_3 treatments, foliar applications of these major elements using up to 44 (NPK trials) or 60 (PO_3 trials) additional lb N/acre did not appear justified on relatively high-yielding groves with standard ground fertilizer programs. Apparently, the extra nutritional needs of citrus trees in the spring (Sanz et al., 1987) were adequately met by the standard soil-applied fertilizer programs. Foliar applications of these major elements still may be useful on South Florida groves with presumably weaker root systems (Albrigo, 1999, 2002). Substituting foliar urea for ground N applications also may be a good practice on sandy soils with nutrient leaching susceptibility.

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