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Effects of Preplant Nitrogen Fertilizer Sources on Strawberry

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Two field trials were conducted to determine effects of preplant N sources on strawberry (*Fragaria ×ananassa* Duch.) growth and yield. The preplant N rate was 50 lb/acre and the N sources were ammonium nitrate (AN; 34% N), ammonium sulfate (AS; 21% N and 24% S), ammonium sulfate nitrate (ASN; 26% N and 14% S), and polymer-coated AS (PCAS; 20% N and 23% S). A no-preplant N control was added. Strawberry plant canopy diameters at 12 weeks after transplanting were not significantly affected by N sources. Preplant N sources significantly affected early and total fruit weight. The highest early yields were found in plots treated with ASN, PCAS, and AS, whereas the lowest early yield was found in the nontreated plots. Total marketable fruit weights were the highest when either AS, ASN, or PCAS were used, which were approximately 12% higher than those of plots treated with AN and the nontreated control. The results indicated that the tested fertilizer sources caused different strawberry yield responses, which might be due to the presence of S, an essential plant nutrient, in AS, ASN and PCAS in the preplant fertilization at rates between 27 and 57 lb/acre. This total marketable response was not observed in plots treated with AN, which does not contain S, and in the nontreated control. Although a total yield difference was not found in plots treated with AN and the nontreated control, adding preplant AN increased early yield by 12%. It appears that there was an early effect of N sources on fruit production, followed by a long term effect of S nutrition on the crop.

Strawberry is one of the most important small fruit crops throughout the world. The US, Spain, and Canada annually plant 55,000, 16,800, and 9700 acres, respectively (Food and Agriculture Organization of the United Nations, 2008). Florida has the second largest production value in the U.S., which generated in 2007 near to $330 million (U.S. Department of Agriculture, 2008). Most Florida's acreage is established under the annual hill system, in which raised planting beds are fumigated for soilborne pest control and covered with polyethylene mulch. The vast majority of strawberry production occurs in the west central part of the state, where sandy soils with rapid infiltration and high water tables are the norm.

The nutrient leaching potential of these soils is relatively high, which has important environmental and crop production implications. From the environmental standpoint, nitrate leaching to ground waters is one of the main causes for rivers and lakes eutrophication and subsequent changes in aquatic life (Finkl and Charlier, 2003; Florida Department of Environmental Protection, 2008; Florida Springs Task Force, 2000). In many bodies of water across Florida, nitrate levels have increased two to three-fold over the past 20 years, reflecting the close link between surface and ground water (Florida Department of Environmental Protection, 2008). One of the main sources of nitrate in ground waters is agricultural fertilizers (Florida Department of Environmental Protection, 2008). Therefore, appropriate fertilization programs are needed to support the current best management practice efforts in the state.

Previous research had shown the diverse effects of preplant N practices and sources on strawberry production. Albregts et al. (1991a) showed that the use of preplant fertilizer on strawberry may not enhance fruit yields and quality, or plant size, if sufficient fertilizer was supplied by the drip irrigation system as soon as the plant roots were able to absorb it. Hochmuth and Cordasco (2009) indicated that the crop would benefit from split applications of preplant and drip-injected fertilizers, which resulted in 10% higher yields, 12% more early fruit, and 5% larger fruit, compared to yields of plots treated with only preplant fertilizer. With regards to N sources, Locascio and Martin (1985) found that when 100% of the N was applied before planting, strawberry marketable fruit number and weight were significantly greater with sulfur-coated urea that with urea, ammonium nitrate (AN) and calcium nitrate. Other research suggested that total marketable fruit yield did not vary because of preplant applications of sulfur-coated urea, AN, and urea in strawberry (Albregts et al., 1991b). Santos and Whidden (2007) reported that plots treated with a preplant application of 50 lb/acre of N, using AN as N source, and the no-preplant N control resulted in the same strawberry yields.

In spite all these dissimilar reports, the nature of the N source may play a significant role on nutrient mineralization, absorption, and leaching in vegetable and small fruit crops. The amount of N mineralized varies markedly due to weather and other factors (Fixen and West, 2002). The overall N use efficiency of a cropping system could be increased by achieving greater uptake efficiency from applied N inputs, by reducing the amount of N lost from soil organic and inorganic N pools, or both (Cassman et al., 2002). Guertal (2000) showed that slow-release N materials had no consistent highly yield advantage over a soluble N source in bell pepper (*Capsicum annuum* L.). However, the same author indicated that if a yield benefit was not widely demonstrated, some other benefits might justify using slow-release fertilizers, such as reduced N leaching, increased N use efficiency, and decreased

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production costs (Guertal, 2009). Thus, the appropriate utilization of soil-applied N sources is important to improve the economic and environmental sustainability of strawberry production. The objective of this study was to determine effects of preplant N sources on strawberry growth and yield.

Materials and Methods

Two trials were conducted during the 2007–08 and 2008–09 strawberry seasons at the Gulf Coast Research and Education Center of the University of Florida, located in Balm, FL. The soil at the experimental site was classified as a Myakka fine sand siliceous hyperthermic Oxyaquic Alorthod. The organic matter content and the soil pH were 1.5% and 7.3, respectively, and were measured 4 weeks before transplanting. Planting beds were 27 inches wide at the base, 24 inches wide at the top, 10 inches high, and spaced 4 ft apart on centers. Finished beds were fumigated with methyl bromide plus chloropicrin (67:33 v/v) at a rate of 350 lb/acre to eliminate soilborne diseases, nematodes and weeds in the soil. Simultaneously, beds were covered with black high-density polyethylene mulch (0.7 mil-thick), and a single line of drip irrigation tubing (25 gal/acre per min; T-Tape Systems International, San Diego, CA) was buried 1 inch deep on bed centers.

The preplant N rate was 50 lb/acre and the N sources were AN (34% N), ammonium sulfate (AS; 21% N and 24% S), ammonium sulfate nitrate (ASN; 26% N and 14% S), and polymer-coated AS (PCAS; 20% N and 23% S). ASN and PCAS were proprietary materials (Honeywell Intl., Morristown, NJ). A nontreated control was added. Two weeks after fumigation, beds were uncovered and measured amounts of each N source were broadcast on the whole area of bed tops and incorporated on the 2 inches of the soil with garden rakes. Immediately after, beds were recovered with the same mulch as previously described. During all the seasons, treatments were established in a randomized complete-block design with six replications. Experimental units were 12.5 ft long (20 plants per plot).

Planting dates during each respective season were 11 Oct. 2007 and 15 Oct. 2008. 'Strawberry Festival' bare-root transplants from certified nurseries in Nova Scotia, Canada, were established 15 inches apart in double rows. Sprinkler irrigation was used 8 h per day for 10 d to establish transplants. With the last irrigation cycle, planted plots received approximately 120 lb/acre of N through the drip lines during the season in daily injections ranging from 0.6 to 1.25 lb/acre per day, depending on the growth stage of the crop,. Plants were irrigated twice per day. Other drip-applied plant nutrients were supplied to the crop following statewide recommendations (Peres et al., 2006).

Strawberry canopy plant diameters were measured perpendicular to the direction of the rows at 12 weeks after transplanting, using five randomly selected plants per plot. Early and total marketable fruit weights were collected starting at 10 weeks after transplanting using every plant of each plot. Early marketable fruit weight was defined as the total marketable fruit of the first 10 harvests, whereas total marketable fruit weight consisted of 22 harvests during each season. Fruit were harvested Monday and Thursday of each week for 11 weeks, starting on the third week in December of each season. A marketable fruit was defined as a fruit without visible blemishes and with at least 75% of red skin. Fertilizer source effects were examined for significance ($P < 0.05$) with the general linear model. Means were compared with a Fisher's protected least significance difference (LSD) test at the 5% significance level.

Results and Discussion

There were no significant season by treatment interactions for all examined variables; thus data from the two seasons were combined for analysis. Strawberry plant canopy diameters at 12 weeks after transplanting were not significantly affected by N sources, with values between 33.0 and 35.7 cm (Table 1). Preplant N sources significantly affected early and total fruit weight. For marketable fruit weight, the highest early yields were found in plots treated with ASN, PCAS, and AS, ranging between 6.2 and 6.8 ton/acre, whereas the lowest early yield was harvested from plots with no preplant N (5.0 ton/acre). Values for total marketable fruit weight were the highest in plots treated with either AS, ASN, or PCAS, ranging between 16.2 and 16.6 ton/acre, which were approximately 12% higher than those of plots treated with AN and the nontreated control.

These results indicated that the tested fertilizer sources caused different strawberry yield responses, which might be due to the presence of S, in AS, ASN and PCAS in the preplant fertilization at rates between 27 and 57 lb/acre. This total marketable response was not observed in plots treated with AN, which does not contain S, and in the nontreated control. Santos et al. (2007) reported significant growth and yield response to S in tomato, as well as in cabbage (*Brassica oleracea* L.) and bell pepper (Susila, 2001). Although a total yield difference was not found in plots treated with AN and the nontreated control, adding preplant AN increased early yield by 12%. Santos and Whidden (2007) had reported that there was no significant effect of preplant AN on the strawberry total yields. However, that study did not address strawberry early yields. In summary, it appears that there was an early effect of N sources on fruit production, followed by a long term effect of S nutrition on the crop.

Table 1. Effects of preplant N sources on plant canopy diameter at 12 weeks after transplanting, and early and total marketable fruit weight, Balm, FL, 2007–08 and 2008–09.

	Rate (lb/acre)		Plant canopy diam	Marketable fruit wt (tons/acre)	
Source	N	S	(cm)	Early	Total
Control	0	0	33.4 a[z]	5.0 c	14.8 b
Ammonium nitrate	50	0	35.7 a	5.6 b	14.6 b
Ammonium sulfate	50	57	33.0 a	6.2 ab	16.5 a
Ammonium sulfate nitrate	50	27	34.2 a	6.8 a	16.2 a
Polymer-coated ammonium sulfate	50	57	34.0 a	6.5 a	16.6 a

[z]Values followed by the same letters do not differ at the 5% significance lever, according to Fisher's LSD test.

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