Spathe width was affected in all cultivars, except 'Majestic Pink', and other than for 'Black Magic', the response was quadratic, indicating no difference between the two shaded treatments (Table 2). Only with 'Black Magic' did spathe width continue to expand as density of shade increased. The data suggest that, in the field, *Zantedeschia* should be provided with $\approx 55\%$ shade to increase scape length and spathe width. Although the intensity of the response differed slightly with cultivar, trends were similar for all cultivars tested.

In summary, the addition of shade for field-grown cut-flower crops is species-dependent. Shade resulted in increases in stem length for all species; however, flower yield was reduced for *Centaurea*, *Eryngium*, and *Zantedeschia*; increased for *Echinops*, and was unaffected for *Anemone* as shade levels increased. Providing 55% shade may be a useful field treatment for

Echinops and *Zantedeschia*, but 67% shade could only be recommended for *Anemone*.

Literature Cited

- Armitage, A.M. 1990. Specialty cut flowers. In: R.A. Larson (ed.). Introduction to floriculture. Academic, New York. (In press.)
- Armitage, A.M., N.G. Seager, I.J. Warrington, and D.H. Greer. 1990. Response of *Oxypetalum caeruleum* to irradiance, temperature and photoperiod. J. Amer. Soc. Hort. Sci. 115:910-914.
- Armitage, A.M. and H.Y. Wetzstein. 1984. Influence of light intensity on flower initiation and differentiation in hybrid geranium. Hort. Science 19:114-116.
- Bunt, A.C. 1973. Effect of season on the carnation (*Dianthus caryophyllus*) II. Flower production. J. Hort. Sci. 48:315-325.
- Craig, R. and D.E. Walker. 1963. The flowering of *Pelargonium hortorum* Bailey seedlings as affected by cumulative solar energy. Proc. Amer. Soc. Hort. Sci. 83:772-776.

- Halevy, A.H. 1984. Light and autonomous induction, p. 65-73. In: D. Vince-Prue, B. Thomas, and K.E. Cockshull (eds.). Light and the flowering process. Academic, New York.
- Holley, W.D. 1959. Some major factors affecting quality and grade of carnations. Colo. Flower Growers Assn. Bul. 109:1-3.
- Klusmeyer, J. and J.A. Martens. 1990. Diversified and specialized keys to cut flower success in Wisconsin. Grower Talks 53(11):22-24.
- Post, K. and J.E. Howland. 1946. Influence of nitrate level and light intensity on the growth and production of greenhouse roses. Proc. Amer. Soc. Hort. Sci. 47:446-450.
- U.S. Department of Agriculture. 1989. Floriculture crops, 1988 summary, SpCr 6-1 (89).
- U.S. Department of Agriculture. 1990. USDA hardiness zone map. Misc. Publ. 1475.
- U.S. Department of Agriculture. 1991. Floriculture crops, 1990 summary. SpCr 6-1 (91).
- Zieslin, N. and A.H. Halevy. 1975. Flower bud atrophy in 'Baccara' roses. II. The effect of environmental factors. Scientia Hort. 3:383-391.

HORTSCIENCE 26(9):1176-1177. 1991.

Preplant Fertilization of Fruiting Microirrigated Strawberry

E.E. Albregts

Agricultural Research and Education Center, University of Florida,
13138 Lewis Gallagher Road, Dover, FL 33527

G.A. Clark and C.D. Stanley

Gulf Coast Research and Education Center, University of Florida, 5007
60th Street East, Bradenton, FL 34203

F.S. Zazueta and A.G. Smajstrla

Agricultural Engineering Department, University of Florida, 101 Frazier
Rogers Hall, Gainesville, FL 32611

Additional index words. *Fragaria* $\times$ *ananassa*, drip irrigation

Abstract. Strawberry (*Fragaria* $\times$ *ananassa* Duch.) was grown for two seasons with microirrigation. Preplant fertilizer treatments of zero, one, two, three, and four times the basic N and K rate of 17 and 15 kg-ha⁻¹, respectively, were applied each season. Additional N and K were applied twice weekly through the microirrigation system at 1.12 and 0.92 kg-ha⁻¹·day⁻¹, respectively. Total marketable fruit yield and marketable fruit per plant were not affected by preplant fertilizer rate. The percentage of marketable fruit increased with increased preplant fertilizer to the 51N-45K (three times basic rate) kg-ha⁻¹ rate the first season. Average fruit weight increased the first season but decreased the second season with increased preplant fertilizer. Plants were larger the first season in treatments receiving preplant fertilizer.

Strawberry in Florida is generally grown on fine sand soils. Although overhead sprinkler irrigation is used for freeze protection and plant establishment, microirrigation is normally used to maintain soil moisture, since water consumption is reduced by this method

(Albregts and Howard, 1977). Fertilization of strawberry in Florida has been with a combination of preplant dry and postplant liquid formulations through the microirrigation system. In a previous study, when all fertilizer was applied preplant, fruit yields of two cultivars with microirrigation were similar to those with overhead sprinkler (Albregts et al., 1990). Locascio and Myers (1975) and Locascio et al. (1977) obtained increased fruit yields when 50% of the N and K was applied preplant compared with all preplant or all through the microirrigation tube. Similar results have been obtained with

tomato (Locascio et al., 1989). Preliminary data indicate that strawberry fruit yields may not be affected by including preplant fertilizer (Albregts et al., 1991). Daily or weekly application of liquid fertilizer does not affect strawberry yield (Locascio et al., 1977). In California, which has a similar growing system as Florida, V. Voth (personal communication) recommends applying all fertilizer preplant or a combination of preplant plus liquid NH₄NO₃ through the microirrigation system. When all fertilizer is injected, rates must be doubled to obtain yields equal to either of the above-mentioned fertilization methods. Some Florida strawberry growers report no advantage to using preplant fertilizer with microirrigation injection of N and K on fine sands.

This study was initiated to evaluate the effect of various rates of preplant N and K while applying a constant rate of N and K through the microirrigation tube on the fruit yield and quality of two strawberry clones.

Strawberry was grown during the 1988-89 and 1989-90 winter seasons on a Seffner fine sand (sandy, siliceous, hyperthermic Quartzipsammentic Haplumbrent) with a pH of 6.4 and using the annual hill cultural system. The experimental area was used the previous 10 years as a strawberry nursery site and fertilized periodically with various amounts of a 10N-4.4P-8.2K fertilizer containing micronutrients. Soil K and P for the experimental area in Aug. 1988 were 20 and 226 mg·kg⁻¹, and 15 and 126 mg·kg⁻¹ in Aug. 1989 respectively, with the Mehlich I extractant (SRIEG, 1983).

Fruit production beds, which were 61 cm wide, 16 cm high, and with 1.22 m bed centers, were fumigated each September with a mixture of 98% methyl bromide and 2% chloropicrin at 336 kg-ha⁻¹ of bed area and mulched with black polyethylene. T-tape microirrigation tubing with a 20-cm emitter spacing and 643 ml/h per emitter discharge rate was placed 8 cm deep in bed center.

Received for publication 14 Jan. 1991. Florida Agricultural Experiment Station Journal Series no. R01272. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Table 1. Effect of preplant fertilizer treatments on fruit quality and plant size of Pajaro and FL 79-1126 clones during 1988-89 and 1989-90 seasons.

Treatment level	Preplant fertilizer or rate (kg·ha ⁻¹)	1988-89 Season			1989-90
		Marketable fruit (%)	Avg fruit wt (g)	February relative plant size (%)	Avg fruit wt (g)
0	0N-0K	68.7	13.5	73	15.0
1	17N-15K	72.4	14.3	98	14.7
2	34N-30K	73.7	14.0	97	14.7
3	51N-45K	74.4	14.4	98	14.6
4	68N-60K	72.2	14.5	100	14.4
Significance		***	**	***	*
Regressions ^a					
Intercept		68.6	13.69	53	14.9
Linear coefficient		4.25**	0.23**	25.8***	-0.13*
Quadratic coefficient		-0.83***	---	3.38***	---

^aLevels of significance from quadratic term when significant, or linear regressions when only the linear term was significant (X = treatment level).

,Significance level from ANOVA test at $P = 0.10, 0.05$, and 0.01 , respectively.

Table 2. Effect of strawberry clones on fruit yield and quality and plant size for 1989-90 season.

Clone	Yield			Avg fruit wt (g)	Marketable fruit/plant	Relative plant size (%)
	Total (Mg·ha ⁻¹)	Marketable (Mg·ha ⁻¹)	Marketable (%)			
Pajaro	30.5 b	23.4 b	76.6 a	15.2 a	25.6 b	90 b
79-1126	41.2 a	27.1 a	65.8 b	14.1 b	31.9 a	100 a
Significance	**	***	***	***	**	**

***Significant in columns by F test, $P = 0.01$ and 0.001 , respectively.

The statistical design was a randomized complete block of five preplant N and K treatments with four replications. Statistical analysis was by standard analysis of variance and regression analyses.

The preplant fertilizer treatments of zero, one, two, three, and four times a basic N (NH_4NO_3) and K (KCl) rate of 17 and 15 kg·ha⁻¹, respectively, were banded 4 cm above the microirrigation tube. In 1988-89 all treatments, except the zero N and K, received P as triple superphosphate at 32 kg·ha⁻¹, which was banded with the N and K. The same amount of P plus 24 kg Mg/ha and 20 kg·ha⁻¹ of a micronutrient mix containing 3% B and Cu, 7% Mn and Zn, and 9% Fe was applied broadcast the second season to all treatments. Additional N as urea and K as KCl, on a twice weekly basis, were applied each season through the microirrigation at 1.12 and 0.93 kg·ha⁻¹·day⁻¹, respectively, for ≈ 180 days the first season (201 and 167 kg N and K/ha) and 185 days the second season (207 and 172 kg N and K/ha). Fertilization with microirrigation began ≈ 1 month after transplanting in 1988 and immediately after transplanting in 1989 and continued until the end of harvest season. Transplanting of locally grown Florida 79-1126 was on 19 Oct. 1988 and of Canadian-grown 'Pajaro' and locally grown Florida 79-1126 on 20 Oct. 1989. Plants were evaluated visually for size four times the first season and three times the second season. Fruit were harvested twice weekly from January through April and graded, counted, and weighed. Soil moisture at the 15-cm depth in plant row was maintained at -5 kPa or wetter. Overhead sprinkler irrigation was provided for 14 days to establish plants and for protection of flowers and fruit during

freezes on 14, 17, and 18 Dec. 1988; 24, 25, and 26 Feb. 1989; and 4, 24, and 25 Dec. 1989.

Total (marketable plus cull) and marketable yields and marketable fruit per plant were not different during both seasons, presumably because of preplant fertilizer treatments (data not presented). This is in contrast to earlier reports (Locascio and Myers, 1975; Locascio et al., 1977, V. Voth, personal communication). There were significant linear and quadratic responses to preplant fertilizer for percentage of marketable fruit the first season (Table 1) but not the second. Average fruit weight increased linearly the first season with increased preplant fertilization but decreased linearly the second season. Significant linear and quadratic responses to preplant fertilizer treatments for plant size were obtained the first season but not the second. During the second season, Florida 79-1126 had higher total and marketable yields, more marketable fruit per plant, and larger plants than 'Pajaro' (Table 2). The percentage of marketable fruit and the average fruit weight were higher for 'Pajaro' than Florida 79-1126. There were no cultivar $\times$ fertilizer treatment interactions.

The response to fertilizer treatments was slightly different for the two seasons. Much of the difference may be related to when and what fertilizer was applied the first season. Phosphorus was not applied to the 0N-0K treatment the first season. In addition, N and K application with microirrigation was initiated 1 month after transplanting the first season rather than at transplanting during the second season. The Aug. 1988 and 1989 soil analyses indicated that soil P was in the very high range, but the soil K level was in the very low range for strawberry. The N con-

tent of fallow sand in Florida is normally very low (Albregts and Howard, 1973). The plants in the 0N-0K treatment during the first season did not appear to grow as rapidly during the first 6 weeks as those in the other treatments. In addition, these plants eventually (Feb. 1990) became normal in size (under Florida conditions) while those in all other treatments appeared to be larger than normal. All plants appeared to grow at similar rates (data not shown) the second season. No visual symptoms of nutrient deficiency were noticed during either season. Since P was more than sufficient in the soil before planting both seasons, the lack of N and K with the 0N-0K treatment early in the second season appears to account for many of the response differences. More of the fruit were rated cull for the 0N-0K treatment than for the other fertilizer treatments because of the small fruit. This difference also is evident in the lower average fruit weight of the marketable fruit. The fruit weight may be related to the N fertilizer levels during each season. Low and excessive N levels can reduce fruit size (Voth et al., 1967).

The results from this study indicate that the use of preplant fertilizer on fruiting strawberry may not enhance fruit yields, fruit quality, or plant size if sufficient fertilizer is supplied by the microirrigation system as soon as the plant roots are able to absorb it.

Literature Cited

- Albregts, E.E. and C.M. Howard. 1973. Influence of fertilizer placement and rates on strawberry production and soil fertility. *Soil Crop Sci. Soc. Fla. Proc.* 32:89-92.
- Albregts, E.E. and C.M. Howard. 1977. Influence of irrigation sources and drip irrigation on strawberries. *Soil Crop Sci. Soc. Fla. Proc.* 37:159-162.
- Albregts, E.E., C.M. Howard, C.K. Chandler, and F.G. Martin. 1990. Fruiting response of strawberry as affected by rates and sources of controlled release N fertilizer and irrigation method. *Soil Crop Sci. Soc. Fla. Proc.* 49:46-49.
- Albregts, E.E., G.A. Clark, C.D. Stanley, F.S. Zazueta, and A.G. Smajstrla. 1991. Preplant fertilizer for microirrigated strawberry. *Proc. 3rd N. Amer. Strawberry Conf.* (In press.)
- Locascio, S.J. and J.M. Myers. 1975. Trickle irrigation and fertilization method for strawberries. *Proc. Fla. State Hort. Soc.* 88:185-189.
- Locascio, S.J., J.M. Myers, and F.G. Martin. 1977. Frequency and rate of fertilization with trickle irrigation for strawberries. *J. Amer. Soc. Hort. Sci.* 102:456-458.
- Locascio, S.J., S.M. Olson, and F.G. Rhoades. 1989. Water quality and time of N and K application for trickle irrigated tomatoes. *J. Amer. Soc. Hort. Sci.* 114:265-268.
- Southern Region Information and Exchange Group on Soil Testing and Plant Analyses (SRIEG 18). 1983. Reference soil test methods for the Southern region of the United States. *Southern Coop. Ser. Bul.* 289. Univ. of Georgia, Athens.
- Voth, V., K. Uriu, and R.S. Bringham. 1967. Effect of high nitrogen applications on yield, earliness, fruit quality, and leaf composition of California strawberries. *Proc. Amer. Soc. Hort. Sci.* 91:249-256.