Strawberry Responses to K Rate on a Fine Sand Soil

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Abstract. Strawberry (*Fragaria* × *ananassa* Duch.) was grown for two seasons on a fine sand soil to study the plant and fruiting response of three cultivars to K rates of 0, 56, 112, 168, and 224 kg·ha⁻¹. 'Dover' total fruit yields increased linearly with rate both seasons while the maximum March yield the first season was with 170 kg K/ha. April yields increased linearly with K rate the first season. 'Tufts' and 'Chandler' responses to K rates were not consistent for monthly or total fruit yield. The average fruit weight of 'Dover' and 'Tufts' decreased linearly with increasing K rate for March and for the season in 1984, while 'Dover' gave a positive linear average fruit weight response to K rate during Apr. 1986. 'Dover' leaf K decreased from December to February, and K deficiency symptoms were expressed by February in treatments receiving lower rates of K. Leaf K concentrations of 'Dover' correlated well with K rate.

Strawberry is generally grown in Florida on somewhat porous sandy soils where K

retention is low. Leaching of fertilizer K can be rapid with Florida sands with excess rainfall or irrigation (Volk, 1964). Polyethylene mulch is included in the cultural regime for strawberry and provides some protection from nutrient leaching. In addition, fertilizer placement will affect nutrient movement in the plant bed (Albregts and Howard, 1984). Results of studies to determine optimum K rate are variable. In England, Bradfield et

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Table 1. Effect of K rate on 'Dover', 'Tufts', and 'Chandler' marketable strawberry fruit yield (Mg·ha⁻¹) during two seasons.

K rate (kg·ha ⁻¹)	Marketable fruit yield (Mg·ha ⁻¹)					
	December	January	February	March	April	Total
<i>'Dover' 1983-84</i>						
0	---	---	6.2	18.4	0.6	25.2
56	---	---	6.7	17.7	0.8	25.2
112	---	---	6.6	22.1	1.0	29.7
168	---	---	6.7	22.7	1.6	31.0
224	---	---	6.5	20.2	1.7	28.4
Linear ^a	---	---	NS	NS	**	*
Quadratic	---	---	NS	NS	**	NS
<i>'Chandler' 1985-86</i>						
0	0.8	5.2	2.1	12.4	7.0	27.6
56	1.2	5.7	1.9	15.2	10.4	34.4
112	1.2	4.8	1.0	15.2	9.1	31.3
168	0.9	5.7	1.8	14.7	8.1	31.2
224	1.1	5.1	1.6	16.5	9.0	32.5
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	*	NS	NS	NS
<i>'Dover' 1985-86</i>						
0	---	2.9	7.1	11.6	1.0	22.6
56	---	1.9	6.4	13.3	1.6	23.2
112	---	2.3	5.6	15.5	1.7	25.0
168	---	2.4	5.0	19.6	1.8	28.8
224	---	1.7	8.8	15.8	1.8	28.1
Linear	---	NS	NS	**	NS	**
Quadratic	---	NS	NS	*	NS	NS

Relationship tested by regression analysis, **P* = 0.05; ***P* = 0.01; NS Nonsignificant.

Table 2. Effect of K rate on marketable average fruit weight of 'Tufts', 'Dover', and 'Chandler' strawberry cultivars during two seasons.

K rate (kg·ha ⁻¹)	Average fruit wt (#fruit)					
	December	January	February	March	April	Season
<i>'Tufts' 1983-84</i>						
0	---	---	20.2	13.8	12.5	13.6
56	---	---	18.8	13.3	12.7	13.3
112	---	---	18.1	13.3	12.3	13.2
168	---	---	18.0	12.4	12.0	12.7
224	---	---	18.9	12.3	11.9	12.4
Linear ^a	---	---	NS	**	NS	**
<i>'Dover' 1983-84</i>						
0	---	---	17.8	13.3	10.6	14.2
56	---	---	17.4	12.6	10.4	14.1
112	---	---	20.2	12.8	10.2	13.9
168	---	---	19.1	12.7	11.0	13.8
224	---	---	17.6	12.4	10.6	13.3
Linear	---	---	NS	*	NS	*
Quadratic	---	---	*	NS	NS	NS
<i>'Dover' 1985-86</i>						
0	---	24.3	16.3	14.6	8.8	15.2
56	---	20.7	17.1	14.7	9.2	15.5
112	---	21.5	16.1	14.8	9.4	14.8
168	---	20.4	17.1	14.9	9.6	15.6
224	---	27.3	16.4	15.9	9.5	15.2
Linear	---	NS	NS	NS	*	NS
Quadratic	---	**	NS	NS	NS	NS

^aRelationship tested by regression analysis, **P* = 0.05; ***P* = 0.01; NS Nonsignificant.

al. (1975) increased flower production and fruit yields with increased rates of K from flowering through fruiting, but increased rates of K gave no yield response in North Carolina (Lineberry and Collins, 1942). In Florida, Locascio and Saxena (1967), using Ona and Kanapaha fine sands containing 37 to 45 ppm K, obtained no positive yield response with K rates from 0 to 202 kg·ha⁻¹ derived from either KCl, KNO₃, or K₂SO₄. Only the K level and the titratable acidity of the fruit increased with increased fertilizer K (Saxena and Locascio, 1968). Another Florida study

also found no fruit yield response to K fertilization with Ona and Blanton fine sands (Dennison and Hall, 1956) containing 18 and 94 ppm K, respectively.

The purpose of our studies was to evaluate the influence of K fertilizer rates on foliar K concentrations and on the plant and fruiting response of three strawberry cultivars.

Studies were conducted at AREC-Dover during the winter seasons of 1983-84 and 1985-86 using the annual hill cultural system. Treatments were a 5 × 2 factorial combination of (a) 0, 56, 112, 168, and 224 kg

K/ha derived from KCl and (b) 'Dover' and 'Tufts' strawberries the first season and 'Dover' and 'Chandler' the second. Plants were grown locally, except 'Chandler', which were grown in Canada. 'Dover' was developed in Florida, and 'Tufts' and 'Chandler' were developed in California. The studies were conducted on a Seffner fine sand (sandy siliceous, hyperthermic, Quartzipsammentic Haplumbrepts). In the top 15 cm of soil, the prefertilization pH was 6.5 while K with the Mehlich I extractant was 23 and 30 ppm for the first and second seasons, respectively.

Plots were 1.2 × 3.7 m (width/length) with four replications. Raised beds were used and fertilized with K as indicated plus (kg·ha⁻¹) 224 N, 20 p, 0.084 B and Cu, 0.2 Mn and Zn, and 2.5 Fe. One-fourth of the fertilizer was incorporated into the raised bed and the remainder was banded in the bed center 4 cm below the surface. In September of each season, beds were fumigated with a 98% methylbromide and 2% chloropicrin mixture, applied at 448 kg·ha⁻¹ and mulched with black polyethylene (1.2 m wide × 0.032 mm thick). Transplants were set on 12 Oct. 1983 and 17 Oct. 1985 with two rows per bed spaced 30 cm between and within rows. Overhead sprinkler irrigation and labeled pesticides were applied as needed. Recently matured leaves of 'Dover' were sampled for K analysis on 2 Dec. 1983, 1 Feb. and 28 Mar. 1984, 9 Dec. 1985, and 11 Feb. 1986. Leaves were rinsed in tap and in distilled water to remove contaminants, dried (60C) to a constant weight, ground, and placed in solution. Total K was determined by flame emission spectroscopy. Because of a Dec. 1983 freeze that killed most flowers and fruit, fruit harvest was delayed until Feb. 1984 and continued to the end of April. Fruit harvest began in Dec. 1985 and ended in Apr. 1986. All ripe fruit were harvested twice weekly, graded, counted, and weighed. Cull (non-marketable) fruit were not weighed the first season. Marketable fruit were those free of rot, not misshapen, and weighed 10 g or more. Plants were rated visually for size and foliage color (1 = yellow red, 6 = dark green) four times each season.

A positive linear K response for total marketable fruit yield occurred with 'Dover' during both seasons (Table 1). April yields increased with increased K rates the first season. Cull yield during the second season was not affected by K rate (data not presented). This result agrees with work by Kirsch (1958). 'Tufts' did not respond to K level at any time.

During the first season, the average fruit weight of 'Tufts' and 'Dover' decreased in March and for the season as K rate increased (Table 2). During the second season, 'Chandler' fruit weight did not vary with treatment, but 'Dover' April fruit weight increased with K rate. Ricketson and Hill (1966) obtained a fruit weight increase with one of two cultivars with increasing leaf K.

Although the *R*² values are highly significant, only about one-half of the variation in the yield was explained by the leaf K concentrations (Table 3). Leaf K in this study

Table 3. Significant regressions of leaf K concentrations on 'Dover' strawberry fruit yield during two seasons.

Sampling date	Month of yield response	Regression equations	Optimum K level	R ²
Mar. 1984	April	-533 + 2544K - 703K ²	1.80	0.48***
Dec. 1985	March	-18131 + 30568K - 6773K ²	2.25	0.46**
Feb. 1986	March	-18508 + 45144K - 14612K ²	1.54	0.51***
Dec. 1985	Total	10509 + 747K	Linear	0.36**
Feb. 1986	Total	7367 + 18528K - 4647K ²	1.99	0.41**

***significant at $P = 0.01$ and 0.001 , respectively.

Table 4. Linear regression of K rate on 'Dover' strawberry leaf K during two seasons.

K rate (kg·ha ⁻¹)	1983-84			1985-86	
	December	February	March	December	February
	Leaf K concn (%)				
0	1.85	0.88	0.54	1.29	0.87
56	1.84	1.01	0.65	1.63	1.10
112	1.96	1.29	0.85	1.90	1.53
168	1.93	1.46	0.96	1.93	1.68
224	2.05	1.57	1.34	1.97	1.81
R ²	0.28**	0.76***	0.72***	0.62***	0.85***

***Regression significant at $P = 0.01$ or 0.001 , respectively.

decreased from flowering (December) through harvest (February through March) (Table 4) as did the optimal leaf concentrations for yield (Table 3). Bould (1964) has given optimum leaf K concentrations at flowering and during fruiting of >2.0% and 1.5%, respectively. Leaf K concentration as great as or greater than these were optimum in this study for fruiting. 'Dover' April yield response the first season and the March yield response the second season would be indicative of K deficiency (Table 1). The K levels in Table 4 explain why a K-yield response was obtained in this study but not by others. Locascio and Saxena (1967) reported that K levels in the leaf were not < 1.40%. Smith and Childers (1960) did not obtain a K fertilizer response, but K foliage levels were > 1.06%. Bould (1964) and Molino et al. (1981) indicated that during fruiting the leaf K should be > 1.5% although Bradfield et al. (1975) gave a value of 1.2% K as optimum. 'Dover' leaf K in this study had decreased to levels < 1% in some treatments by February or March. This decrease indicated that insufficient K was being absorbed by 'Dover' plants to support optimum fruit production. Potassium deficiency symptoms were displayed in February by 'Dover' plants both seasons but not by 'Tufts' or 'Chandler'. Voth et al. (1961) and Voth (1974) indicated that strawberry plants do not respond to fertilizer K in California because of sufficient levels of K in the soil.

Florida strawberry plant breeders select genotypes under conditions of high K fertilization while California breeders rely on naturally occurring soil K. Efficiency of nutrient use may be reduced under Florida conditions

1973). Potassium use by snap beans (Gerloff, 1976) and beets (Pimentel et al., 1973) and P use of snap beans (Whiteaker, 1976) under nutritional stress was less with inefficient lines than with efficient lines. When nutritional stress was removed, plants re-

sponded normally. This nutritional response may be related to substitution of Na for K (Makmur et al., 1978), but not all genotypes are able to do so (Shea et al., 1968). Although it was not measured in this study, the root mass of California clones may have been larger and more widely distributed than that of Florida clones and were adapted to prevailing K concentrations in the soil.

Visual color ratings indicated a significant response by 'Dover' to K rate both seasons, but which did not occur until 14 Mar. 1984 and 25 Feb. 1986. In 1984, foliage color ratings were 2.3, 3.4, 4.2, 4.6, and 4.7 for 0, 56, 112, 168, and 224 kg K/ha, respectively. The corresponding 1986 foliage color ratings were 3.3, 4.4, 5.1, 5.0, and 5.1. Both ratings were linear with K rate at $P = 0.01$ and 0.05, respectively. Visual ratings of plant size were not affected by K rates during either season (data not presented). However, Smith and Childers (1960) noted that when leaf K was ≤ 1%, plant growth was restricted. The foliar K concentrations in this study were not <1% until after December, but before February. Plants in Florida usually reach their maximum growth for the harvest season in February. Most of the fruit were produced after January and thus the K supplied by reserves in the soil and/or the K fertilizer was sufficient for plant growth, but not necessarily for 'Dover' fruit yield.

The cost of the K fertilizer to produce the additional fruit to obtain the maximum yields for 'Tufts' and 'Chandler' would have been ≈ 17¢ and 2¢ per flat, respectively, assuming 40¢/kg for K from KCl and 6 kg of fruit per flat. The average price per flat of Florida strawberries for the 1984-85 through 1988-89 seasons was \$7.20. Thus, the O K rate may not be the most economical for California-developed cultivars grown in Florida.

In summary a Florida-developed cultivar, Dover, gave positive fruit yield responses to K rates during two seasons. Two California-developed cultivars did not give significant

yield responses to K rates. 'Dover' plants with the lower K rates exhibited K deficiency symptoms by February each season. California cultivars did not develop K deficiency symptoms. Leaf K concentrations of 'Dover' correlated well with fertilizer K rate.

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