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EFFECTS OF POTASSIUM SOURCE AND RATE AND NITROGEN RATE ON STRAWBERRY TISSUE COMPOSITION AND FRUIT YIELD

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ABSTRACT

Strawberries were grown during three seasons on Ona and Kanapaha fine sands to evaluate their response to N and K rates and sources of K. Fruit yields were not significantly influenced by N rates from 46 to 180 lb/acre. Increased rates of K, from 35 to 180 lb/acre had no significant effect on total yield during two seasons. In the third season, a significant reduction in total yield occurred as the rate of applied K was increased from 0 to 130 lb/acre. This yield reduction was associated possibly with a K-Mg antagonism. The N and K composition of leaf tissue was increased by increased rates of applied N and K respectively.

Sulfate, chloride and nitrate sources of K produced the same leaf tissue composition and total fruit yields.

INTRODUCTION

A number of workers have studied the response of strawberries to N and K rates. Positive yield responses to increased rates of N to 100 lb/acre have been reported (8, 12, 14) while other workers obtained no yield response (2, 3, 5, 8). In some experiments fertilization with K has also resulted in yield increases (11, 13, 15) but had no effect in others (8, 13, 14). Generally, N and K content of the leaf tissue was increased by application of the respective element and yield responses occurred on soils low in available N and K. Most of the above reported work was done using the matted row system of production or before the introduction of polyethylene as a mulch.

Experiments reported here were conducted to evaluate the effect of N and K rates, and three K sources on yield and tissue composition of strawberries.

EXPERIMENTAL PROCEDURE

Fertility experiments were conducted on Kanapaha fine sands during 1964-65 and 1965-66 and on an Ona fine sand in 1966-67. These soils had been in use for production of other vegetables. From soil test data, the soil pH ranged from 5.8 to 6.1, Ca from 328 to 1,000 lb/acre, Mg from 63 to 95 lb/acre and K from 73 to 89 lb/acre. Treatments were factorial combinations of two or three K sources, three K rates and three N rates. Treatments were arranged in randomized block design and replicated three times. Potassium sources studied were the sulfate, chloride and nitrate. In the 1964-65 season, the study did not include the nitrate source. Rates of K and N used are shown in Table 1. The P level applied was a uniform application at the rate of 70 lb/acre from superphosphate.

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Table 1. Fertilizer N and K rates used in strawberry experiments.

Treatment	Season 1964-65	1965-66	1966-67
		lb/acre N	
Nitrogen			
N_1	60	52	46
N_2	120	100	96
N_3	180	148	146
		lb/acre K	
Potassium			
K_1	60	35	0
K_2	120	90	65
K_3	180	145	130

Table 2. Main effects of N and K rates on the total nitrogen and potassium content of strawberry foliage at two sample dates during three seasons.

Treatment	Tissue sample date 1965 3/26	4/16	1966 3/17	4/18	1967 2/23	3/23
			% total N			
N_1[a]	3.35[b]	2.77	3.76	3.43	3.67	3.61
N_2	3.57	2.90	3.90	3.59	3.77	3.47
N_3	3.51	3.07	3.81	3.70	3.73	3.53
F value:[c]	Q*	L*	Q*	L**	N.S.	N.S.
			% K			
K_1	1.81	1.85	1.51	1.40	1.73	1.40
K_2	1.95	2.19	1.54	1.55	1.96	1.69
K_3	2.05	2.54	1.59	1.60	1.99	1.72
F value:	L**	L**	L**	L**	L**	L**

[a] For N and K rates see Table 1.
[b] Values are mean of 27.
[c] Q = Quadratic, L = Linear.

All soil areas used were broadcast fumigated with 1,3-dichloropropene at the rate of 18 gallons/acre six weeks before treatment application. In mid-October, one-half of the fertilizer was applied broadcast on 8 x 25 feet plots, disked in lightly and 4-foot beds made up leaving 2 feet on each side of the bed as guard area. The remaining half of the fertilizer was placed in a narrow band in the center of the bed at a depth of 4 inches. Overhead irrigation was then applied at the rate of 0.5 in/acre before 1.5 mil black polyethylene mulch was applied. Florida Ninety strawberry plants were set with a hand trowel in two rows 12 x 12 inches apart on the bed through the film.

Soil samples were taken bimonthly beginning one month after planting from the broadcast fertilized area. Saturated paste extracts from the samples were analyzed for nitrate-nitrogen, soluble salts, Ca, Mg and K (10) and data expressed as ppm at field capacity.

Foliar samples were taken from recently matured leaves at various intervals throughout the season. They were dry ashed, and analyzed for N (1), K, Ca, and Mg (10). Twice a week, fruits were harvested, graded and reported as number of 12-pint flats/acre.

Results and Discussion

In two of the three years of these experiments, leaf N early in the season increased as the rate of applied N was increased from the first to the second increment (Table 2). A further increase in the N level beyond 120 lb/acre had no effect on tissue N. Samples taken later in the seasons showed that the leaf tissue N content increased linearly with increased rate of applied N. In the 1966-67 season, rates of applied N from 46 to 146 lb/acre had no effect on tissue N. However, the mean tissue values of 3.72 and 3.54% at the early and late samplings respectively, were equal to most samples in the other years.

The effect of K rate on tissue K content was significant at all samplings (Table 2). Tissue K content increased linearly with increased rate of applied K in all three seasons. This increase in foliar K composition in response to K fertilization ranged from .20 to .49 percent. Potassium sources (K_2SO_4, KNO_3 and KCl) had little differential effect on either N or K content of the leaf in any year. Leaf tissue Ca and Mg contents (Tables 3 and 4) were decreased linearly with increased rates of applied K in all seasons except that for Mg in 1966-67. Generally, the Ca and Mg tissue levels were lower early in the season than at the later growth stages.

Nitrogen rates from 46 to 180 lb/acre had no significant effect on the marketable yield in any year (Table 5). Increased rates of K from 0 to 180 lb/acre had no significant effect on yield in two seasons. However, fruit yield tended to decrease with an increase in the rate of applied K. In 1966-67, a significant reduction in yield occurred as the rate of applied K increased from 0 to 130 lb/acre. Potassium sources, K_2SO_4, KNO_3 and KCl, had no significant effect on yield during the three seasons.

Correlation coefficients between leaf tissue N, K, Ca and Mg composition at two sampling dates

Table 3. Main effects of K rate and source on the percent Ca content of strawberry foliage during 3 seasons.

Treatment	Tissue sample date 1965 3/26	1965 4/16	1966 3/17	1966 4/18	1967 2/23	1967 3/23
			K rate effects			
K_1	.71	1.27	.83	1.09	.65	.96
K_2	.70	1.17	.80	1.11	.61	.81
K_3	.69	1.13	.80	1.04	.56	.79
F value:	N.S.	L*	L**	N.S.	L*	L*
			K source effects			
K_2SO_4	.67	1.16	.80	1.09	.61	.86
KNO_3	--	--	.81	1.07	.63	.85
KCl	.70	1.23	.83	1.09	.59	.85
F value:	N.S.	K_2SO_4 vs. KCl*	N.S.	N.S.	K_2SO_4 + KCl vs. KNO_3*	N.S.

and yield are shown in Table 6. Generally, signicant correlations were few and these were low. This would indicate that these nutrients were not the yield limiting factor. During the 1966-67 season, yields decreased significantly with increased tissue composition of N, K and Mg. This, along with a significant yield reduction with increased rates of applied K, suggested another factor possibly that excessive soluble salt may have been the limiting factor. A summary of soil N, K and soluble salt data are shown in Tables 7 and 8. The main effect of N rate on average nitrate and soluble salt levels of the soil solution (mean of samples taken bimonthly) during each season is shown in Table 7. Nitrate and soluble salt levels increased linearly with

Table 4. Main effects of K rates and source on the percent Mg content of strawberry foliage during 3 seasons.

Treatment	Tissue sample date 1965 3/26	1965 4/16	1966 3/17	1966 4/18	1967 2/23	1967 3/23
			K rate effects			
K_1	.37	.33	.58	.69	.60	.48
K_2	.36	.37	.57	.67	.60	.42
K_3	.31	.31	.58	.66	.72	.44
F value:	L*	L*	N.S.	L*	N.S.	N.S.
			K source effects			
K_2SO_4	.34	.35	.58	.68	.70	.44
KNO_3	--	--	.58	.66	.62	.44
KCl	.35	.32	.57	.68	.60	.46
F value:	N.S.	K_2SO_4 vs KCl*	N.S.	N.S.	K_2SO_4 vs KCl*	N.S.

Table 5. Effects of N and K rate and K source on the total marketable yield of strawberries expressed as flats per acre.

Treatment	Season 1964-65	1965-66	1966-67
	N rate effects		
N_1	718	1030	571
N_2	750	1083	638
N_3	721	1066	565
F value:	N.S.	N.S.	N.S.
	K rate effects		
K_1	760	1075	656
K_2	720	1066	590
K_3	708	1039	528
F value:	N.S.	N.S.	L*
	K source effects		
K_2SO_4	744	1080	574
KNO_3	--	1039	614
KCl	715	1060	585
F value:	N.S.	N.S.	N.S.

increased rates of applied N in each year. Both of these values were considerably higher during the 1966-67 season. Average K and soluble salt values as influenced by K rates are shown in Table 8. A significant increase in soil K occurred with increased rates of applied K. However, increases in the soluble salt levels in response to increased K rates were not significant.

Plant growth and fruit yields were average in the first season, above average in the second season, and below average in the third season. Positive responses to N or K rates or K sources were not obtained even though yields varied by

Table 6. Correlation coefficients between foliar composition and total yield.

Tissue component	Tissue Sample Date 1965 3/26	1965 4/16	1966 3/17	1966 4/18	1967 2/23	1967 3/23
			r values			
N	-.027	.191	.007	-.110	-.061	-.284**
K	-.127	-.024	.117	.124	-.142	-.308**
Ca	.032	.308*	-.105	.022	.137	-.064
Mg	.006	.142	.078	.026	.129	-.281*

Table 7. Main effects of N rate on the mean nitrate (N) and soluble salt levels (S.S.) from soil samples. Data from three bimonthly samples.

Nitrogen rate	Season					
	1964-65		1965-66		1966-67	
	ppm in soil solution					
	N	S.S.	N	S.S.	N	S.S.
N_1	50	544	112	1085	223	1271
N_2	78	673	192	1529	312	1739
N_3	79	650	228	1860	356	1964
F value:	L*	N.S.	L**	L**	L*	L**

season from 528 to 1,083 flats/acre. Also, these treatments had little effect on fruit quality as measured by titratable acidity, soluble solids or fruit firmness (16). A lack of strawberry yield response to K application has been previously reported in Florida (8) and elsewhere (13, 14). Preliminary studies by Sutton (18) indicated that little yield response occurred to increased rates of 6-8-8 fertilizer beyond 600 lb/acre. This suggests that factors other than N and K might commonly be limiting yields. In the studies reported here, tissue composition of N, K, Ca and Mg were above the established threshold values for deficiency (4, 6, 7) and soluble salt levels calculated at field capacity appeared to be below toxic levels. However, with overhead irrigation, soil moisture was somewhat below field capacity between irrigations and injury to excessive salts may have been a factor. Strawberries are relatively sensitive to soluble salts and yield reductions of 50 percent have been reported by soil conductivity values of 2.3 mmhos per cm (about 2,950 ppm) (9). In the experiment reported here, however, N had more effect on the soluble salt level than did K rate or source. Relatively low Mg tissue content and high Ca and K contents suggest that yield reductions associated with increased K rates might be due to K-Mg and Ca-Mg antagonism (6, 17). Soil Mg levels were also low as compared with Ca values in the last season when significant yield reductions occurred with increased K rates. During the previous season when yields were much higher, Ca and Mg in the tissue were also higher.

Table 8. Main effects of K rate on the mean K and soluble salt levels (S.S.) from soil samples. Data from three bimonthly samples.

Potassium rate	Season					
	1964-65		1965-66		1966-67	
	ppm in soil solution					
	K	S.S.	K	S.S.	K	S.S.
K_1	52	605	56	1355	74	1565
K_2	64	601	88	1517	134	1608
K_3	98	660	123	1603	200	1799
F value:	L**	N.S.	L**	N.S.	L**	N.S.

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