Research - Strawberry Nutrition

The Effect of Increased Nitrogen and Potassium Levels within the Sap of Strawberry Leaf Petioles on Overall Yield and Quality of Strawberry Fruit as Affected by Cultivar (Year 2).

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Justification:

Among the recent techniques for N and K management in vegetable and small fruit has been the use of petiole sap analysis to determine supplemental fertilizer needs. Sap tests to determine nutrient status of crops have been used to a limited degree since the 1920s. Until recently, however, these tests have been considered semi-quantitative at best. Within the last 20 years, advances have been made in determining sap NO_3 and K in various crops using Merck EM Quant test strips. More recently, the introduction of the electrode by Horiba Instruments called a "Cardy meter" has a flat membrane capable of providing a reading for NO_3 or K concentration in a non diluted sap. Researchers using the Cardy NO_3 electrode with non diluted sap have also shown that sap NO_3 is correlated to petiole NO_3 expressed on a dry weight basis. The Cardy K meter has been used to establish sufficient levels of K in petiole sap for eggplant. Plant sap analysis can help achieve optimum fertilization of strawberries. Petiole sap testing is not intended to replace standardized laboratory analytical procedures for whole leaves or dried petioles. However, analyzing fresh plant sap for N and K concentrations is a quick procedure to determine the N and K levels in plants, the results of which can be used in guiding N and K applications to strawberry plants. However, proper use of the equipment and sample techniques is vital to a reliable reading.

Work by investigators in California provides evidence of the benefits derived from strategically spaced nitrogen applications in the spring. Higher fruit yields in their studies were associated with nitrogen applied during vegetative growth and fruiting. During this period, petiole nitrate nitrogen values were 3000 – 4000 ppm nitrogen, which appears to be adequate. In general nitrate nitrogen should never drop below 500 ppm. Exceptions to this general rule would be during early winter and after fruiting. During plant establishment (fall) petiole nitrate nitrogen should approach 1500 – 2000 ppm. This work concurs with work in North Carolina as well. However, these numbers reflect the response of only one cultivar, Chandler.

Objectives:

1. Examine the effectiveness of the use of the Cardy Meter as a reliable source to be used by growers to monitor the Nitrogen and Potassium levels within the petiole sap throughout the production season.

2. Examine the levels of both nitrogen and potassium to maximize yield, yet maintain fruit quality as it is affected by cultivar selection.

Methods and Materials

Field experiments were conducted during the 2004-2005 growing seasons. The experimental site was located at the Clemson Coastal Research and Education Center (CREC), Charleston, South Carolina. The soil was Younges fine loamy sand. Strawberry cultivars chosen for this study were: 'Chandler', 'Gaviota' 'Camarosa' and Comeo Real. 'Chlandler', 'Gaviota', 'Gaviota' and 'Cameo Real' transplants were obtained from commercial nursery sources. These transplants were grown for five weeks usng the NC Strawberry Transplant Growing Recommendations (Poling and Monks, 1994). Plug plants were field planted on October 19. A randomized complete block design was used with six replications of each of the four fertilizer treatments using each of the three cultivars. All plots received sixty units of nitrogen and potassium prior to transplanting. The fertilizer was broadcast and incorporated once bed formation had occurred but prior to fumigation and the black plastic mulch operation. Plugs were transplanted in 3 feet (.9m) wide fumigated, black plastic mulched beds, 8 inches (20 cm) high with 6 feet (1.8 m) between centers of each bed. Plots consisted of a single mulched bed, 5 feet long (1.5 m) long, with a double row of plants staggered 12 inches (30 cm) apart within row and 14 inches (36 cm) between rows. Each plot contained 10 plants. Irrigation and fertigation began the following March. Fertilizer treatments consisted of: (1) 2.5 lb/week, totaling 30 lb of N and K; (2) 5.0 lb/week, totaling 60 lb N and K; (3) 7.5 lb/week, totaling 90 lbs of N and K, and (4)10 lb/week, totaling 120 lbs of N and K. Fertigation started on a weekly basis beginning February 27 and ending May 14, twelve week total. Fertilizer was a liquid (8-0-8) with minors purchased from a local distribution center. It was applied using four Dosmatic A-40 injectors, one for each treatment. Stantard pesticide practices were used for the growing season following the NC Strawberry Growing Recommendations (Poling and Monks, 1994). Mature fruit was harvested by hand twice weekly (Monday and Thursday) beginning at the end of March and continuing through the last week of May, nine weeks. Berries were harvested by hand and graded according to the USDA grading standards (USDA, 1997). Berries were individually counted, graded and weighed and divided into US No. 1, defects (small and misshapen berries), and rots (*Botrytis criteria*). Differences in yields and fruit quality were detected on a weekly basis using analysis of variance (ANOVA).

Results

The majority of variation in the plant growth and yield of strawberry plants were attributed to cultivar by weekly harvest effects (Table 1). However, there was also an interaction effect of from the fertigation treatment by the weekly harvest. The fertigation effect on cultivar selection was only seen in the marketable number and weight of the fruit harvested as well as the sugar level and the firmness of the fruit. Cultivars performed differently as expected (Table 2). ‘Gaviota’ was the first harvested in any significant number. ‘Chandler’ produced quality berries early then as the season progressed the number of defects as well as rots increased. ‘Camerosa’ produced early and yielded consistent. There were fewer rots than overall than ‘Chandler’ and much easier to pick. ‘Cameo Real’ produced a large bush with a lot of unmarketable fruit. Because of the size of the bush it made it difficult to harvest.

Fertility effects saw little affect during each week of harvest until the third week (Table 3). At the highest fertility rates marketable number as well as weight went down significantly. However so did the defect number and weight. Visually the plants seemed to show a market visual reduction in growth and fruit set. Also this effect was not persistent in the data. The marketable number and weight continued to fluctuate each week.

Cultivar selection played a major role in there response to fertigation treatments (Table 4). ‘Chandler’ was the most effected by increased fertility levels greater that the 5 lb per acre per week. The marketable fruit number as well as marketable weight was reduced significantly. Fruit firmness was also reduced above this level. Sugars levels were reduced significantly only at the highest fertigation rate. ‘Gamerosa’ was the least effect by the fertigation rates. Increasing the levels of nitrogen and potassium did little to affect any of the parameters measured. However, there was a slight increase found with marketable fruit size at the higher rates. ‘Gaviota’ yields were reduced at any of the fertigation rates over 2.5 lb per acre per week. The highest fruit number and fruit weight was with the lowest fertility rate. Firmness as well as sugar levels were unaffected by the fertigation rates. ‘Cameo Real’ was the least effected by the fertigation rates. Marketable fruit number and weight were reduced only at the highest fertigation rate. Fruit quality was unaffected.

Tissue analysis showed a continued increase in nitrogen levels with increase fertigation rates with a decrease in potassium levels above the 5 lb per acre per week. At the present time this is unexplainable. Final crown counts only showed a cultivar effect with ‘Gaviota’ having the fewest number.

Table 1. Percent of treatment sums of squares of the model partitioned into main and interaction effects for strawberry yield and growth characteristics on weekly harvests, of four fertigation treatments, on four different cultivars.

Source of Variation	Mark. No.	Mark. Wt.	Def. No.	Def. Wt.	Rot No.	Rot Wt.	Tissue $N0_3$	Tissue K_20	Sugars Brix	Force (g/in^2)	Crown /Plant
Reps	0	0	2	2	1	1	6	6	2	2	5
Harvest Weeks (H)	56**	56**	37**	40**	46**	48**	23**	27**	12**	5**	----------
Cultivar (C)	8**	5*	15**	13**	10**	5**	18**	6**	3*	45**	60**
H x C	13**	12**	15**	14**	9**	5**	3	3	2	0	----------
Fertiltiy Treatments (T)	0	0	0	0	0	3	31**	5**	0	0	2
H x T	2**	2*	2**	4**	2*	4**	1	1	0	0	----------
C x T	2**	4**	0	1	1	0	0	3	5**	8*	7
H x C x T	1	1	2	2	3	2	1	5	6	2	----------
Error	18	20	27	24	28	32	17	44	68	38	26

[z] The sum of squares for each of the factors in the ANOVA converted to a percentage of the total sum of squares.
[**] F values significant at $P = 0.01$.

Table 2. Interaction of weekly harvests and cultivar selection on individual harvest characteristics (pooled over four fertigation treatments). [z]

Harvest Weeks[y]	**Marketable No./Plot**	**Marketable wt. Grams/plot**	**Defect No./Plot**	**Defect Wt. Grams/plot**	**Rots No./Plot**	**Rot Wt Grams/plot**
Chandler						
4/4 – 4/10	4.65	88.00	2.30	31.25	0.75	13.85
4/11 – 4/17	64.05	1314.15	18.65	299.30	4.60	80.15
4/18 – 4/24	104.55	1807.65	46.10	555.70	9.10	125.75
4/25 – 5/1	108.35	1764.90	67.80	605.05	15.20	143.10
5/2 – 5/8	112.40	1591.60	47.40	438.50	7.05	54.75
5/9 – 5/15	58.15	767.00	23.25	204.10	6.80	46.25
5/16 – 5/22	79.80	1074.65	35.10	262.35	40.35	395.45
5/23 – 5/29	52.85	697.10	31.80	193.75	23.70	231.25
5-30 – 6/5	45.80	530.70	13.65	86.90	27.50	287.35
Camerosa						
4/4 – 4/10	9.70	173.20	2.90	38.70	0.20	2.30
4/11 – 4/17	61.35	1195.70	17.40	282.00	3.80	61.05
4/18 – 4/24	111.90	1935.85	53.65	616.65	3.75	46.85
4/25 – 5/1	124.50	2033.35	59.20	552.75	4.00	40.45
5/2 – 5/8	125.80	1844.10	38.45	381.15	3.35	29.45
5/9 – 5/15	103.20	1417.65	26.85	239.45	5.50	35.00
5/16 – 5/22	86.95	1421.15	16.70	138.60	29.75	373.20
5/23 – 5/29	68.65	1057.60	28.35	190.50	14.05	149.60
5-30 – 6/5	50.25	724.70	17.15	124.00	27.75	282.90
Gaviota						
4/4 – 4/10	38.00	752.75	3.25	35.60	1.30	17.25
4/11 – 4/17	63.95	1254.60	16.05	255.85	4.25	75.10
4/18 – 4/24	67.70	1240.75	10.15	116.35	1.10	28.45
4/25 – 5/1	51.30	914.35	10.75	91.65	0.35	3.10
5/2 – 5/8	75.60	1509.70	10.05	101.15	0.90	7.80
5/9 – 5/15	56.40	824.95	6.75	49.80	1.00	7.95
5/16 – 5/22	36.25	628.30	9.50	55.40	10.45	231.15
5/23 – 5/29	52.70	909.25	14.90	99.15	4.95	71.30
5-30 – 6/5	36.35	540.15	17.00	118.65	13.30	146.45
Cameo Real						
4/4 – 4/10	4.05	74.55	3.30	47.55	0.05	1.00
4/11 – 4/17	57.20	1162.80	16.35	276.80	4.00	53.85
4/18 – 4/24	112.95	2195.05	58.15	699.70	5.90	75.33
4/25 – 5/1	113.45	1873.25	56.90	555.35	7.50	83.90
5/2 – 5/8	120.45	1889.35	36.85	362.85	2.70	23.50
5/9 – 5/15	102.35	1352.75	30.25	194.30	2.70	16.70
5/16 – 5/22	91.35	1346.75	26.65	245.30	18.90	220.70
5/23 – 5/29	48.35	674.55	23.80	163.30	13.30	139.10
5-30 – 6/5	44.40	667.80	11.35	101.15	20.35	216.75
LSD 0.05	11.15	212.70	7.79	77.96	4.45	56.22

[z]Plots consisted of twelve plants replicated three times
[y]Plots were harvested twice per week (Monday and Thursday)

Table 3. . Interaction of weekly harvests and fertigation treatments on individual harvest characteristics (pooled over four cultivars).[z]

Harvest Weeks[y]	**Fertigation Treatments/week**[x]	**Marketable No./Plot**	**Marketable wt.Grams/plot**	**Defect No./Plot**	**Defect Wt. Grams/plot**	**Rots No./Plot**	**Rot Wt Grams/plot**
4/4 – 4/10	2.5lb/acre	12.50	249.40	3.10	41.75	0.70	11.85
	5.0 lb/acre	13.30	255.25	1.75	23.05	0.35	5.50
	7.5 lb acre	15.95	293.85	3.30	42.00	0.55	7.75
	10.0 lb acre	14.65	290.00	3.60	46.30	0.70	9.30
4/11 – 4/17	2.5lb/acre	58.60	1127.25	22.70	371.50	6.45	89.60
	5.0 lb/acre	61.45	1254.95	22.75	352.55	3.55	43.85
	7.5 lb acre	60.90	1224.95	4.80	81.55	0.60	6.75
	10.0 lb acre	65.60	1320.10	18.20	308.35	6.70	129.95
4/18 – 4/24	2.5lb/acre	105.05	1867.70	44.45	526.35	5.15	74.98
	5.0 lb/acre	94.00	1659.20	38.60	445.15	6.05	77.50
	7.5 lb acre	103.85	1968.60	48.10	587.70	4.75	72.00
	10.0 lb acre	94.20	1685.80	36.90	429.20	3.90	51.90
4/25 – 5/1	2.5lb/acre	108.05	1784.30	48.35	448.22	5.45	66.25
	5.0 lb/acre	97.00	1591.75	50.40	450.90	9.30	76.80
	7.5 lb acre	101.70	1792.80	51.50	493.20	7.05	70.75
	10.0 lb acre	90.85	1417.00	44.40	412.50	6.65	56.75
5/2 – 5/8	2.5lb/acre	113.95	1801.65	32.55	331.00	3.60	31.10
	5.0 lb/acre	107.05	1658.20	34.50	333.60	3.30	25.35
	7.5 lb acre	115.65	1815.05	34.75	330.40	3.20	27.20
	10.0 lb acre	97.60	1558.85	30.95	288.65	3.90	31.85
5/9 – 5/15	2.5lb/acre	80.80	1078.50	16.05	153.00	4.00	24.85
	5.0 lb/acre	79.55	1118.25	22.25	187.20	3.60	25.85
	7.5 lb acre	80.05	1065.35	27.45	197.95	4.85	31.25
	10.0 lb acre	79.70	1100.25	21.35	149.50	3.55	24.50
5/16 – 5/22	2.5lb/acre	68.80	1143.45	21.75	177.45	25.35	304.90
	5.0 lb/acre	76.90	1141.00	20.95	164.95	24.10	280.90
	7.5 lb acre	81.40	1207.40	24.75	215.80	20.70	240.40
	10.0 lb acre	67.25	979.00	20.50	143.45	29.30	394.30
5/23 – 5/29	2.5lb/acre	46.90	668.35	22.65	146.75	15.65	159.60
	5.0 lb/acre	58.75	906.95	25.85	162.25	13.90	154.20
	7.5 lb acre	56.90	855.50	27.90	180.35	14.80	162.25
	10.0 lb acre	60.00	907.70	22.45	157.35	11.65	115.20
5-30 – 6/5	2.5lb/acre	29.40	428.95	13.20	87.30	18.90	197.65
	5.0 lb/acre	52.90	731.10	16.55	127.45	19.95	230.80
	7.5 lb acre	42.60	623.70	15.80	114.10	24.70	194.90
	10.0 lb acre	51.90	679.60	13.60	101.85	25.35	310.10
	LSD 0.05	11.45	212.70	7.79	77.96	4.50	56.22

[z]Plots consisted of twelve plants replicated three times
[y]Plots were harvested twice per week (Monday and Thursday)
[x]Fertigation treatments were applied once a week, Friday, using a single Dosamatic A-40 injector per treatments, a total of four injectors.

Table 4. Interaction of fertigation treatments and cultivar selection on individual harvest characteristics (pooled over nine weekly harvests).[z]

Fertility Treatments/week[y]	Marketable No./Plot	Marketable wt.Grams/plot	Sugar Brix[x]	Force g/in^2)[w]
Chandler				
2.5lb/acre	69.24	1080.84	7.54	0.17
5.0 lb/acre	74.53	1137.53	8.02	0.18
7.5 lb acre	68.49	1062.84	8.15	0.15
10.0 lb acre	68.00	1001.33	7.67	0.11
Camerosa				
2.5lb/acre	78.82	1301.87	7.56	0.31
5.0 lb/acre	86.76	1331.00	7.65	0.32
7.5 lb acre	84.11	1364.91	7.69	0.31
10.0 lb acre	80.22	1249.02	7.74	0.30
Goviota				
2.5lb/acre	68.73	1240.51	7.71	0.27
5.0 lb/acre	54.98	979.98	7.05	0.27
7.5 lb acre	55.96	1002.56	7.06	0.26
10.0 lb acre	52.89	948.96	7.67	0.26
Cameo Real				
2.5lb/acre	80.56	1248.67	7.70	0.34
5.0 lb/acre	68.58	1136.67	7.59	0.33
7.5 lb acre	84.33	1391.11	7.44	0.34
10.0 lb acre	75.22	1217.71	7.82	0.34
LSD 0.05	7.63	70.89	0.76	0.02

[z]Plots consisted of twelve plants replicated three times
[y]Fertigation treatments were applied once a week, Friday, using a single Dosamatic A-40 injector per treatments, a total of four injectors.
[x]Sugar readings were taken with a refractometer (Abbe Mark 11) on six fruit per plot and then averaged.
[w]Force measurements were taken with a Accuforce Cadet on six fruit per plot and then averaged.

Table 5. Effects of fetigation treatments on petiole nitrogen and potassium levels (pooled over four cultivars and four sampling dates). [z]

Fertility Treatments/week	**Tissue $N0_3$[x] (ppm)**	**Tissue K_20[x] (ppm)**
2.5lb/acre	233.55	1741.67
5.0 lb/acre	373.50	1995.00
7.5 lb acre	427.83	1836.67
10.0 lb acre	476.17	1748.00
LSD 0.05	26.62	116.00

[z]Plots consisted of twelve plants replicated three times
[y]Fertigation treatments were applied once a week, Friday, using a single Dosamatic A-40 injector per treatments, a total of four injectors.
[x]Tissue samples were recorded using a Candy Meter.

Table 6. Effect of cultivar selection on the final crown development of individual plants (pooled over four fertigation treatments). [z]

Cultivar	**Final Crowns Crowns/plant**
Chandler	7.75
Camerosa	7.10
Gaviota	4.35
Cameo Real	7.20
LSD 0.05	0.65

[z]Six plants per plot were dug at the end of the season and crown number counted then averaged.