Nitrogen and Potassium Fertilization Effects on Yield, Fruit Quality, and Leaf Composition of 'Stanley' Prunes

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Abstract. The increase of the N level in leaves and fruits of 10-yr-old 'Stanley' prunes was found significant after soil application of 793.8 g N alone or combined with 1020.6 g K. Potassium levels of leaf and fruit began to show significant increases the third year after K fertilization. Ammonium nitrate favors accumulation of Mn in leaves. Higher rates of N alone or combined with K significantly increased yields. Increasing leaf K did not affect fruit yield unless leaf N was also increased. Nitrogen had no effect on titratable acids and soluble solids of the fruit. High K increased the titratable acids in fruits in light crop years. The results of the present study suggest that leaf K should be above 2.0% and leaf N should be above 2.1% for optimum production of 'Stanley' prunes.

In 1952, Cain and Boynton (1) reported that N and K fertilization increased yield and fruit set of 'Italian' prunes in Western New York. They concluded that the gain from fertilization did not overcome the loss associated with leaf mottle condition under study. Since then, little work has been done on fertilization of other prune cultivars. The 'Stanley' prune is highly productive and has gained commercial importance in recent years. The fruits are as large as 'Italian' prunes with excellent dessert and processing quality, and are similar in appearance to the 'Italian' prunes. The objective of this study was to establish levels of N and K in the leaves associated with optimum yield and quality of 'Stanley' prunes.

Materials and Methods

In 1962, a block of 56, 10-yr-old 'Stanley' prune trees was selected for study in the Cornell Pomology Experimental Orchard at Sodus, New York. The orchard was located on Dunkirk silt loam with an average pH of 5.2 in the top 6 inches of soil. The trees were spaced 20 x 20 ft apart and had received standard commercial care since planting and there was no significant difference in nutritional status (Table 5).

Early in 1963, the 56 trees were divided into 8 single tree plots with seven replications of similar size and vigor. The 8 individual tree plots were randomized and received various rates of N and K fertilizer over a 5-yr period as indicated in Table 1.

Ammonium nitrate was the source of N and potassium sulfate was the source of K. The fertilizer was broadcast under the spread of the branches annually in late April. The orchard was clean-cultivated in the spring, followed by a summer cover crop. Excessive shoot growth was observed in 1964 and in 1965 under high rates of N. The N program was then modified in 1966. The K level was found adequate in the 1962 and 1963 leaf analyses. Potassium fertilizer was omitted in 1964 and 1967 and reduced in 1966. Applying K fertilizer annually could reduce the leaf Mg to an undesirable level.

A leaf sample of 30 mid-shoot leaves was collected from each of the 56 trees in August and analyzed for P, Ca, K, Mg, Zn, Mn, Fe, Cu, and B by photo-electric spectrograph. Total N was determined by Kjeldahl.

Yield of individual trees was recorded each year from 1963 through 1967. Fruit size was determined by weighing 100 prunes taken at random from each tree just before harvest.

Titratable acid determinations were made on a 250-g sample consisting of a slice from each of 25 prunes. Each sample was homogenized in 20 ml of distilled water in a Waring blender. The homogenate was filtered through a double-layer of cheesecloth and a 20 ml aliquot was titrated to pH 8.1 with 0.1 N NaOH. Soluble solids were determined by refractometer. Fruit samples for mineral analysis were freeze-dried and analyzed spectrographically. The LSD was calculated according to Snedecor and Cochran (10).

Results and Discussion

Yield. As the result of prolonged, severe drought which caused heavy fruit shriveling and pre-harvest drop in 1964 and unseasonable cold rainy weather during the fruit-setting period in 1966, the yield of these 2 years was low compared to others (Table 2). High rate of N with addition of K appeared to have sustained a better yield under the unfavorable weather conditions of 1964 and 1966. Application of 476.3 g or 793.8 g N alone significantly increased yields in 1966 and 1967 compared to no N treatments. Potassium alone did not affect yields. Nitrogen at the rate of 793.8 g plus 1020.6 g K significantly increased yield 3 out of 5 years in comparison with the no N treatments. The 5-yr total of an individual tree indicated that higher rates of N alone or combined with K yielded 15-24% more than the check and 16-25% more than the treatments of 1020.6 g K alone, but the difference was not

Table 1. Rates of application of N and K to 'Stanley' prune trees.

	Plots (actual N and K g/tree)							
Year	None	158.8N	476.3N	793.8N	612.4K	1020.6K	476.3N 612.4K	793.8N 1020.6K
1963	None	158.8N	476.3N	793.8N	612.4K	1020.6K	476.3N 612.4K	793.8N 1020.8K
1964	None	158.8N	476.3N	793.8N	None	None	476.3N	793.8N
1965	None	158.8N	476.3N	793.8N	612.4K	1020.6K	476.3N 612.4K	793.8N 1020.6K
1966	None	158.8N	317.5N	476.3N	199.6K	399.2K	317.5N 199.6K	476.3N 399.2K
1967	None	158.8N	476.3N	793.8N	None	None	476.3N	793.8N

Table 2. Fruit yields of 'Stanley' prunes as influenced by N and K fertilization.

Fertilizer treatment (g/tree)	Fruit yields (kg/tree)[z]					
	1963	1964[y]	1965	1966	1967	5-year total
None	129.4	36.7	131.0	33.2	108.3	438.6
158.8N	139.1	48.2	139.5	46.0	122.2	495.0
476.3N	132.5	47.6	142.4	53.1	131.3	506.9
793.8N	131.1	50.4	135.5	54.8	131.4	503.2
612.4K	134.1	36.3	133.9	35.7	118.4	458.4
1020.6K	128.6	27.8	109.5	33.4	108.6	407.9
476.3N + 612.4K	146.5	50.8	137.2	52.5	135.3	522.3
793.8N + 1020.6K	127.4	63.5	147.9	55.4	132.7	526.9
LSD (.05)	ns	17.3	ns	17.9	20.7	ns
(.01)		23.1				

[z]Mean of 7 trees.

[y]Pre-harvest drop fruits were not included.

Table 3. Fruit size of 'Stanley' prunes as influenced by N and K fertilization.

Fertilizer treatment (g/tree)	Fruit size (g per fruit)[z]					
	1963	1964	1965	1966	1967	5-year average
None	27.4	32.2	33.1	41.8	24.6	31.8
158.8N	27.6	31.4	34.3	42.1	26.2	32.3
476.3N	28.8	31.4	34.5	43.3	28.7	33.3
793.8N	27.1	32.2	34.9	41.3	28.2	32.7
612.4K	29.0	31.2	34.6	42.3	26.1	32.6
1020.6K	27.4	32.4	34.5	41.8	25.1	32.3
476.3N + 612.4K	28.5	31.8	37.3	43.1	30.0	34.1
793.8N + 1020.6K	28.9	30.1	35.2	44.1	28.7	33.4
LSD (.05)	ns	ns	ns	ns	3.6	ns
(.01)					4.9	

[z]Mean of 700 fruits.

statistically significant.

Fruit size. There was no difference in fruit size the first 4 years, but in the 5th year larger fruits were associated with the higher rates of N (Table 3). The largest fruits developed in the 476.3 g N plus 612.4 g K treatment. Smaller fruit size was associated with heavy crop loads. Potassium alone had no significant effect on fruit size.

Table 4. Titrarable acids and soluble solids of 'Stanley' prunes as influenced by N and K fertilization.

Fertilizer treatment (g/tree)	Titratable acids (%)[z,y]				
	1963	1964	1965	1966	1967
None	0.55	0.80	0.65	0.81	0.81
158.8N	0.51	0.86	0.68	0.85	0.81
476.3N	0.52	0.85	0.65	0.85	0.80
793.8N	0.52	0.82	0.62	0.84	0.83
612.4K	0.49	0.88	0.70	0.86	0.83
1020.6K	0.52	0.98	0.69	0.89	0.88
476.3N + 612.4K	0.48	0.89	0.68	0.91	0.85
793.6N + 1020.6K	0.54	0.89	0.71	0.95	0.87
LSD (.05)	ns	0.08	ns	0.05	ns
(.01)		0.12		0.08	
	Soluble solids (%)[z]				
None	11.9	17.0	12.7	17.3	11.5
158.8N	12.3	17.7	12.8	16.3	12.2
476.3N	11.8	16.9	12.8	15.8	12.2
793.8N	11.9	15.8	13.0	16.7	13.0
612.4K	12.2	17.8	13.7	16.3	13.0
1020.6K	12.2	18.8	13.6	17.8	12.2
476.3N + 612.4K	12.1	17.0	13.4	16.4	12.6
793.8N + 1020.6K	11.8	15.7	12.3	15.7	11.8
LSD	ns	ns	ns	ns	ns

[z]Mean of 7 determinations

[y]Titratable acids were calculated as % of malic acid.

Titratable acids and soluble solids. Potassium increased the acid content of fruit significantly in 1964 and again in 1966 when the crops were light (Table 4). The role played by K in governing the level of acids in the fruit is not yet fully

Table 5. Nutrient concn in the leaves and fruits of 'Stanley' prunes as influenced by N and K fertilization.

Sampling date	Nutrient element	N and K fertilizer applied (g/tree)[z]								LSD	
		None	158.8N	476.3N	793.8N	612.4K	1020.6K	476.3N 612.4K	793.8N 1020.6K	(.05)	(.01)
					Leaf analysis (% dry wt)[z]						
1962	N (%)	2.41	2.50	2.38	2.47	2.49	2.52	2.43	2.40	ns	
Aug. 15	K (%)	3.23	3.23	3.23	3.41	3.42	3.20	3.25	3.39	ns	
	Mn (ppm)	88.0	79.7	88.0	83.8	85.5	83.8	81.3	76.5	ns	
1963	N (%)	2.72	2.78	2.83	2.89	2.72	2.67	2.80	2.84	0.10	0.14
Aug. 19	K (%)	3.02	3.46	3.50	3.32	3.44	3.10	3.35	3.35	ns	
	Mn (ppm)	111.3	100.1	108.0	111.4	108.0	108.3	106.6	99.3	ns	
1964	N (%)	2.26	2.30	2.38	2.40	2.21	2.20	2.37	2.45	0.10	0.14
Aug. 30	K (%)	2.67	2.76	2.68	2.64	2.80	3.05	3.09	3.00	ns	
	Mn (ppm)	66.8	74.3	79.8	84.3	79.8	70.5	94.3	80.5	ns	
1965	N (%)	2.19	2.29	2.42	2.46	2.18	2.11	2.41	2.49	0.15	0.20
Aug. 24	K (%)	2.69	2.94	3.00	2.77	3.54	3.59	3.74	3.84	0.50	0.66
	Mn (ppm)	75.4	88.0	91.6	110.3	89.4	78.3	127.6	109.9	34.5	46.3
1966	N (%)	2.02	2.14	2.23	2.24	2.05	2.00	2.21	2.25	0.10	0.14
Aug. 30	K (%)	2.49	2.82	2.78	2.42	3.15	3.19	3.31	3.40	0.41	0.55
	Mn (ppm)	62.0	70.4	80.4	102.1	78.0	70.6	126.6	93.7	31.4	42.0
1967	N (%)	1.92	2.05	2.13	2.20	1.98	1.97	2.15	2.20	0.10	0.14
Aug. 30	K (%)	2.18	2.37	2.24	2.26	2.88	2.93	3.03	2.92	0.41	0.55
	Mn (ppm)	119.3	145.2	143.6	187.0	140.7	137.0	198.0	178.4	44.2	59.1
					Fruit analysis (% dry wt)[z]						
1964	N (%)	0.90	0.83	0.89	0.87	0.79	0.85	0.87	0.93	ns	
Sept. 8	K (%)	0.97	1.07	1.00	1.00	1.05	1.08	1.09	1.10	ns	
	Mn (ppm)	7.4	8.3	7.2	8.0	8.3	7.4	8.6	9.2	ns	
1965	N (%)	0.85	0.93	0.93	0.96	0.77	0.76	0.94	0.98	0.11	0.15
Sept. 20	K (%)	1.02	1.12	1.10	1.06	1.17	1.16	1.22	1.26	0.14	0.18
	Mn (ppm)	8.0	8.3	8.6	7.9	8.9	7.4	8.9	8.4		

[z]Mean of 7 determinations.

understood. It has been reported that K fertilization did increase titratable acids in peaches (5) and in apples (2, 3) but not in sweet cherries (4). Soluble solids were not affected by N or K. The large seasonal difference in soluble solids (11.8-18.8%) is likely due to the size of the crop since soluble solids appear to be higher in a low crop situation.

Leaf and fruit composition. Only 3 nutrient elements (N, K and Mn) were affected by treatments (Table 5). The initial levels of leaf N (2.38-2.52%) and K (3.20-3.42%) were considered adequate for plums in Western New York. The increase of leaf N the first year and fruit N the third year, by either higher rates of N or higher rates of N combined with K, was statistically significant when compared to the no N treatments. The K level of leaf and fruit was not affected by fertilizer treatments until the third year. Ammonium nitrate favors accumulation of Mn in the leaves. Similar effects on peaches have been reported (8, 9). Mineral content of all elements is lower in fruit than in leaves. The leaf analysis indicates that maintaining an adequate level of leaf K alone did not improve yield unless the leaf N was also maintained sufficiently high. Leaf K less than 2.0% was considered to be the threshold for developing deficiency symptoms in plums (6, 7). The results of the present study suggest that the leaf K should be maintained above 2.0% and the level of leaf N should be maintained not less than 2.1% for optimum production of 'Stanley' prunes.

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Anthocyanin in Flowers of *Chrysanthemum morifolium* Ram. During Anthesis in Relation to Sugar Content[1]

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Abstract. Anthocyanin concentration decreased and sugar concentration increased in petals of *C. morifolium* cv. Orchid Queen during petal expansion in a greenhouse from the day of first coloration until full bloom. No correlation was found between either total sugar or reducing sugar and anthocyanin concn. Dry wt % decreased also during petal expansion so that sugar was an increasing proportion of the dry matter. Anthocyanin was at higher concn in petals expanding in Oct. than in July or Nov., but reducing sugar was higher in Nov. and total sugar was higher in Nov. and July than in Oct. The possibility of insufficient sugar substrate for anthocyanin synthesis under these conditions is discounted.

Intense coloration in red chrysanthemum flowers occurs under cool temp and bright light intensity. Similar climatic conditions favor anthocyanin accumulation in apple fruit (9, 14) and *Spirodela* leaves (12). Anthocyanin accumulates in fruit tissues under conditions that favor sugar production, and a relationship between sugar concn and anthocyanin synthesis has been noted since 1899 (2). Several tissues have been shown to redden after infusion of sugar (2, 3, 4, 12, 13). Although a direct pathway for synthesis of anthocyanin from sugars has not been proven, Thimann et al. (13) did find a close relationship between reducing sugars and anthocyanin. We attempted to determine if a correlation between reducing sugars or total sugars and anthocyanin could be found in red chrysanthemum flowers at any stage of anthesis from time of first coloration until pollen shed and if the more intense pigmentation in autumn relative to summer was associated with higher sugar content of petals.

Materials and Methods

Plants of cv. Orchid Queen were grown in a glasshouse in Athens, Georgia, in which max summer temp were moderated by a fan-pad evaporative cooling system and winter temp were 15°C night/20-25°C day. Shading by titanium oxide paint on the glass was provided from May 20 until Sept. 15. Standard commercial cultural procedures were followed: photoperiods controlled according to schedules for cut flowers, high fertility (150 ppm N and 56 ppm K continuous injection of water), peat-amended clay soil. The plants and flowers were of size and quality to meet upper commercial grades. The pink blossoms of 'Orchid Queen' are sensitive to climatic factors for color intensity.

Plantings were made on May 11, July 27, and Aug. 31, 1968 and subjected to short photoperiods so that flowers would be at optimum stage for harvest on Aug. 3, Oct. 19, and Nov. 16. Petals became visible and first developed color on July 16, Oct. 1, and Nov. 7, respectively. On those dates and every third day thereafter until pollen shed, 7 blossoms were taken from each of 7 plants and were analyzed for anthocyanin and sugar content. Anthocyanin was determined by boiling 0.5 g samples of outer ray petals in 1% HCl-methanol for 2 min and letting stand for 4 hr. Filtration through glass fiber filters using additional

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