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J. Amer. Soc. Hort. Sci. 104(6):852–857. 1979.

Relationships between Growth of Bell Peppers (*Capsicum annuum* L.) and Nutrient Accumulation during Ontogeny in Field Environments[1]

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Additional index words. sampling techniques, dry matter, growth parameters

Abstract. **'Keystone Resistant Giant' pepper plants, grown at a population of 48,000/ha, were sampled, fractionated, dried, weighed and analyzed for macroelement content every 14 days between 28 and 112 days after transplanting. The highest specific accumulation rate for N, P, K, Ca and Mg occurred 28 to 42 days after transplanting, but the highest absolute nutrient uptake rate was during 56 to 70 days after transplanting, a period when fruit growth was rapid. N, P and K accumulated in leaves-plus-petioles, stems and fruit whereas Ca and Mg were abundant in leaves-plus-petioles but was quite low in fruit tissue. By 98 days after transplanting, the plants had absorbed the following amounts of nutrients in kg/ha: 118 N, 15 P, 123 K, 41 Ca, and 32 Mg. Total dry matter was 4758 kg/ha at the same time. Leaf efficiency as measured by mean net assimilation rate was high during fruit set and growth but declined after commercial harvest. A relatively low leaf area index and a correspondingly high mean net assimilation rate suggested that increased plant populations would result in increased efficiency. There were 114,500 marketable fruits/ha picked during 2 harvests which weighed 13.4 MT.**

Nutrient concentrations in pepper tissues (leaves, fruit, etc.) have been correlated with yields. Increasing P fertilizer resulted in leaf P concentrations of 0.20, 0.35 and 0.49% and increased K fertilizer resulted in leaf K concentrations of 3.05, 4.46 and 5.26% (1). Ozaki and Ozaki (13) found higher N, P and K concentrations in leaf tissue, and lower concentrations in stems and still less in root tissue. Higher concentrations of Ca and Mg were found in mature leaves than in stems or roots. Sufficiency levels of N, P, K, Ca, and Mg in mature vegetative tissues were found to be 1.56, 0.30, 3.34, 1.53 and 0.6%, respectively, and 1.75, 0.38, 2.90, 0.16 and 0.22%, respectively, in fruit tissue (11). Pepper leaf P concentration ranged from 0.28 to 0.43% (14). Chlorotic pepper leaves had 0.25% Mg compared to 0.58% in non-chlorotic ones. When plants were sequentially sampled over time, leaf N varied from 4.2 to 6.4% (5). Total P accumulation by pepper plants increased with additions of N fertilizer (18). Pepper yields were closely associated with both fertilizer and leaf tissue N (17). The optimum level of leaf N for 6 week-old transplants was 3.7% dry weight (7).

Rational fertilization schedules require information on full-season growth trends and on changes in nutrient concentrations or nutrient demand over time. The objectives of this study were to quantify growth and nutrient accumulation during ontogeny and relate rates of nutrient accumulation to growth phenomena via growth analysis concepts.

Materials and Methods

'Keystone Resistant Giant' pepper plants were transplanted to the field on April 30 and spaced 23 x 91 cm (48,000/ha). The soil was an Orangeburg loamy sand with a pH of 6.0. It had an initial nutrient content, in kg/ha, of 168 P, 278 K,

[1]Received for publication May 31, 1979. Paper No. 6015 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh. The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of products named, nor criticism of similar ones not mentioned.
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168 Ca and 235 Mg, as determined by extracting the soil with 0.05 N HCl + 0.025 N H_2SO_4. Prior to planting, 44 kg/ha of P as concentrated superphosphate and 83 kg/ha of K as KCl were broadcast and incorporated by disking. Nitrogen as NH_4NO_3 was applied in 2 increments of 45 kg/ha at 7 and 28 days after transplanting.

Each plot initially contained 12 three-plant subunits guarded on 4 sides by other plants so that sampling procedures would not influence remaining subunits. All measurements were based on 4 replications per sample date. Initial nutrient content was determined by analyzing 28 plants selected at transplanting. Beginning at 4 weeks after transplanting and continuing at 2-week intervals, 3 whole plants/plot were severed at the soil surface, bagged, and held at 4°C overnight. The plants were then fractionated into leaves plus petioles, stems, and fruit (when present). All fractions were dried at 70° under forced air, weighed, and held for mineral analyses.

Additional guard plants were harvested on each sample date and used to determine leaf to leaf-plus-petiole ratios (dry weight basis) and to determine specific leaf area. The area of a representative sample of fresh leaf laminae (500 to 700 cm^2) was measured with an optical planimeter (4) which had been successively calibrated with black paper and green leaf tissue of known area. A minimum of 2 instrument loadings was measured on each sample date, and each measured sample was subsequently dried under forced air at 70°C and weighed. Specific leaf area was calculated as cm^2 of fresh leaf laminae per g of dry, laminar tissue. The mean specific leaf area of all measurements per sample date was used in subsequent calculations to convert dry leaf weight from a 3-plant sample to its equivalent in fresh leaf area. The leaf area index was calculated as a ratio of leaf surface to soil surface. Mean values of relevant growth and nutrient accumulation parameters were calculated using published formulae (8, 9, 15). No estimate of leaf loss was made, but physical losses via senescence and abscission of old leaves were evident after 98 days.

N was determined by Kjeldahl, P by spectrophotometer, K by flame photometry, Ca and Mg by atomic absorption spectrophotometry.

Commercial-grade and cull fruit from each unsampled, 3-plant subunit were harvested at 63 and 73 days after transplanting (27 and 24 plants/plot, respectively). Fruits were graded into U.S. No. 1, U.S. No. 2 and culls. Yields from both harvests were subsequently converted to their dry-matter equivalents and included in cumulative estimates of dry matter production and total nutrient uptake.

Results and Discussion

The distribution of dry matter and macroelements among plant parts is shown in Fig. 1. Because many of the measured quantities were maximal at 98 days after transplanting, the data are expressed as percentages of the 98 day total. The curves are thus cumulative over time and plant part so that the vertical distance between 2 adjacent lines represents the percentage of the 98 day total in a given plant fraction at a given time. The relative distribution of N, P, and K was similar in all fractions. There was an apparent lag in K accumulation between 70 and 84 days which we believe was related to the commercial harvests. Accumulation of both P and K was positive in all fractions through 112 days from transplanting, but N accumulation was maximal at 98 days. Most of the Mg and Ca was in the vegetative fractions.

Leaves contributed most of the dry weight through 42 days after transplanting, decreased at 56-days and represented about 25% of the total thereafter (Table 1). The proportion of dry matter contributed by stems, was minimal near the time of commercial harvest. The increase in stem percentage after 84 days was a consequence of renewed vegetative growth following

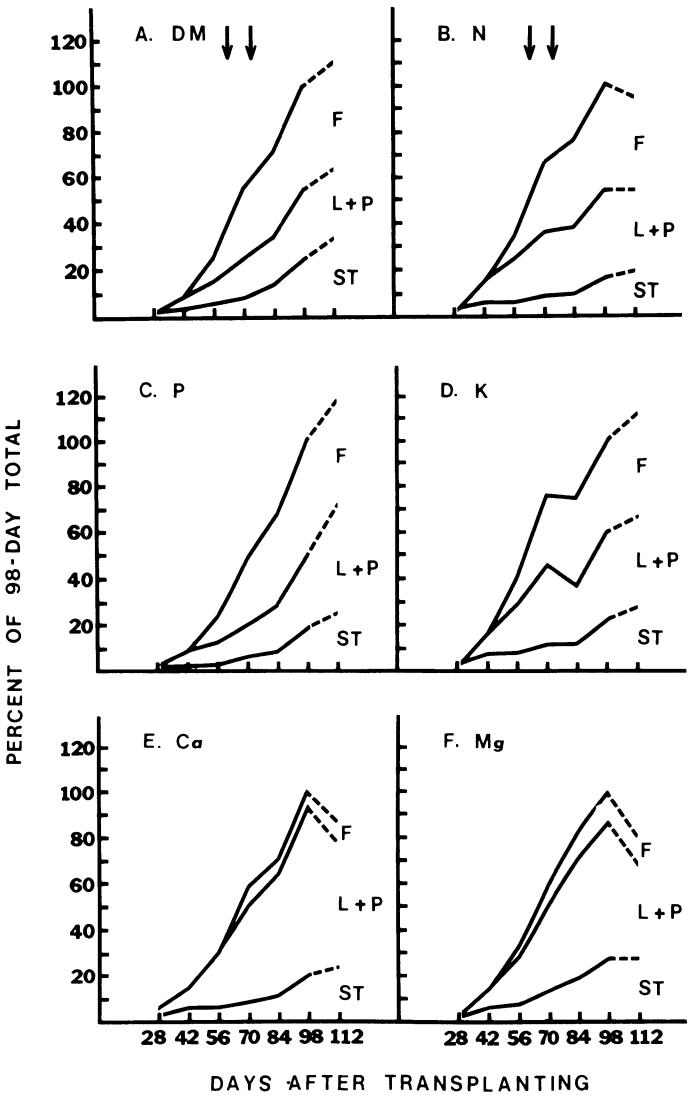

Fig. 1. Dry matter (DM) and elemental accumulation in fruit (F), leaf and petiole (L&P), and stem (ST) tissues during ontogeny of bell peppers. Arrows at the top indicate dates of commercial harvest (63 and 73 days after transplanting). (Absolute quantities of dry matter and elements are given in Tables 1, 3, 4, 5, 6, and 7).

Table 1. Total dry weight (TDW) and % of total contributed by stems, leaves, petioles and fruit at each sampling, specific leaf area (SLA) and leaf area index (LAI) of bell peppers during an entire growing season.

Time after transplanting (days)	Dry wt (% of total)				TDW (kg/ha)	SLA (cm^2/g)	LAI
	Stem	Leaf	Pet.	Fruit			
0				–	21		
28	22	68	9	–	81	198	0.11
42	37	53	8	2	411	175	0.38
56	18	38	6	37	1158	150	0.66
70	16	27	5	52	2615	160	1.12
84	18	25	4	53	3388	144	1.19
98	24	25	5	46	4758	152	1.82
112	30	23	4	43	5111	139	1.61
LSD 5%	4	5	2	9	57	16	0.26

Table 2. Seasonal trends in parameters used to describe growth of bell peppers during an entire growing season.

Sampling interval (days after transplanting)	Growth parameters[z] (per day)				
	$\overline{RGR}$ (%)	$\overline{CGR}$ (kg/ha)	$\overline{FGR}$ (kg/ha)	$\overline{LGR}$ (m^2/ha)	$\overline{NAR}$ (g/m^2)
0-28	4.7	2.2	--	32.4	3.8
28-42	12.0	23.5	0.7	193.2	11.4
42-56	7.4	53.4	30.3	199.1	10.7
56-70	5.7	104.0	66.8	329.8	11.9
70-84	1.9	55.3	31.6	50.1	5.2
84-98	2.4	97.8	26.5	450.0	6.7
98-112	0.5	25.2	00.0	-147.3	1.7
LSD 5%	2.6	52.0	30.7	252.8	1.4

[z]$\overline{RGR}$ = mean relative growth rate, $\overline{CGR}$ = mean crop growth rate, $\overline{FGR}$ = mean fruit growth rate, $\overline{LGR}$ = mean leaf growth rate, $\overline{NAR}$ = mean net assimilation rate.

fruit removal. Total dry weight accumulation continued throughout the sampling period. The specific leaf area decreased to 56 days after transplanting, then remained constant for the remainder of the season. Decreased specific leaf area presumably indicated thicker leaves. The specific leaf area for peppers was slightly less than that reported for potatoes (9).

The leaf area index increased through the 98-day sampling then decreased slightly at the 112-day sampling (Table 1). The maximum leaf area index for peppers (1.8) was less than those recorded by McCollum and Miller (unpublished data) for cucumbers (2.0 at 42 days from seeding) and sweet potatoes (4.8 at 76 days after transplanting). Maximum leaf area indices for other crops measured on number of days after emergence were snapbean, 2.8 after 48 days (6); potato, 3.2 after 50 days (9); soybean, 4.8 after 78 days; corn, 3.2 after 67 days (3); and grain sorghum, 5.5 after 65 days (16).

Most of the growth parameters indicate that maximum rate of growth occurred between 56 and 70 days after transplanting (Table 2). The mean leaf growth rate was considerably lower in the 70-84 day period, followed by a large increase in the next period and then a negative value in the last sampling interval. Some of those changes may have been associated with the commercial fruit harvests 63 and 73 days after transplanting. For example, the mean net assimilation rate, a measure of leaf efficiency, declined markedly during the 70-84 day interval, increased slightly during the 84-98 day interval, then decreased further. We postulate that removal of the fruit, which served as a sink for assimilates, caused the decline in leaf efficiency. Other workers have cited reduced mean net assimilation rates when the sink (tubers) was removed from potatoes (2, 12).

Although the data are not provided, there were 5.84 fruits formed per plant of which 3.25 (55.7%) were removed during the 2 harvests. Of those fruit harvested, 44, 30, and 26% were graded U.S. No. 1, U.S. No. 2 and cull, respectively. The 2.59 fruit formed but not removed in the commercial harvests were included in the sequential fruit samples. Expressed on a fresh weight basis, 546 g of fruit per plant were formed of which 338 g (61.5%) were harvested commercially. Of those removed during harvest, 55% were U.S. No. 1 (average 130 g), 28% were U.S. No. 2 (average 97 g) and 17% were cull (average 62 g). The sequential samples contained 208 g of fruit.

The mean crop growth rate peaked 56-70 days after transplanting, declined in the next interval, then increased sharply (Table 2). On the other hand, mean fruit growth rate declined after the 56-70 day interval. The difference between the 2 measurements showed a resumption of vegetative growth after commercial harvest.

Leaf-plus-petiole and stem N (%) increased from 0 to 42 days after transplanting, then decreased for the remainder of the sampling period (Table 3). Fruit N was highest in young fruit 42 days from transplanting, declined sharply by the next sample, then remained relatively constant. Total N uptake, kg/ha, increased throughout, except at the last sampling date. Presumably, leaves that abscised and were not recovered accounted for the decline at the last sampling date. The most rapid increase in N uptake was during the first portion of the sampling period.

The uptake rates for total N and fruit N were greatest in the 56-70 day sampling interval. The first commercial harvest was also made during that interval. On the other hand, specific N accumulation, expressed as mg N uptake/g d.m./day, was highest during the 28-42 day interval.

The accumulation of P by bell peppers was continuous throughout the experimental period (Table 4). After 28 days, leaves and petioles contained 82% while the stems contained 18% of the total P. By 84 days after transplanting, 30% of total P was in leaves and petioles, 12% in stems, and 58% in fruits. The P concentrations in leaves and petioles, stems, and

Table 3. N concentration, total accumulation, and distribution among above-ground portions. N uptake rate (NUR), specific N accumulation rate (SNACR), and fruit N uptake rate (NFUR) by bell peppers.

Time after transplanting (days)	N concentration (% dry wt)			Total N (kg/ha)	N distribution (% of total)			Sampling interval (days)	NUR[z]	SNACR[y]	NFUR[z]
	Stem	Leaf and Petiole	Fruit		Stem	Leaf and Petiole	Fruit				
0	2.2	3.1	–	0.6	29	71	–				
28	3.0	4.9	–	3.7	14	86	–	0-28	0.13	2.47	–
42	3.8	5.0	3.8	18.5	31	67	2	28-42	1.06	5.45	<0.01
56	2.6	4.6	2.8	41.3	13	57	30	42-56	1.63	2.26	0.87
79	2.5	3.9	2.6	78.4	13	41	45	56-70	2.65	1.43	1.69
84	2.0	3.3	2.6	90.6	14	36	51	70-84	0.87	0.34	0.73
98	1.8	3.2	2.4	118.2	17	38	45	84-98	1.97	0.48	0.49
112	1.5	2.9	2.2	111.1	21	36	44	98-112	-0.51	-0.10	-0.35
LSD 5%	0.3	0.5	0.2	16.3	4	6	8		1.61	1.29	0.84

[z]NUR = Nitrogen uptake rate (kg/ha per day).

[y]SNACR = Specific N accumulation rate (mg N/g dry matter per day).

[x]NFUR = Fruit N uptake rate (kg/ha per day).

Table 4. P concentration, total accumulation and distribution of above-ground portions, P uptake rate (PUR), specific P accumulation rate (SPACR), and fruit P uptake rate (PFUR) by bell peppers.

Time after transplanting (days)	P concentration (% dry wt)			Total P (kg/ha)	P distribution (% of total)			Sampling interval (days)	PURz PURz	SPACRy SPACRy	PFURx PFURx
	Stem	Leaf and Petiole	Fruit		Stem	Leaf and Petiole	Fruit				
0	0.40	0.43	–	0.1	35	65	–				
28	0.29	0.38	–	0.3	18	82	–	0-28	0.01	0.16	–
42	0.32	0.32	0.44	1.3	36	61	3	28-42	0.07	0.38	0.01
56	0.20	0.29	0.38	3.6	12	42	46	42-56	0.16	0.22	0.11
70	0.17	0.27	0.31	7.0	10	32	58	56-70	0.25	0.14	0.18
84	0.20	0.30	0.33	10.2	12	30	58	70-84	0.22	0.08	0.14
98	0.25	0.33	0.34	14.8	31	19	50	84-98	0.33	0.04	0.09
112	0.24	0.47	0.32	17.2	38	21	41	98-112	0.17	0.04	–0.03
LSD 5%	0.05	0.06	0.07	2.2	5	7	11		0.21	0.10	0.12

[z]PUR = P uptake rate (kg/ha per day).

[y]SPACR = Specific P accumulation rate (mg P/g dry matter per day).

[x]PFUR = Fruit P uptake rate (kg/ha per day).

Table 5. K concentration, total accumulation and distribution among above-ground portions, K uptake rate (KUR), specific K accumulation rate (SKACR), and fruit K uptake rate (KFUR) by bell peppers.

Time after transplanting (days)	K concentration (% dry wt)			Total K (kg/ha)	K distribution (% of total)			Sampling interval (days)	KURz KURz	SKACRy SKACRy	KFURx KFURx
	Stem	Leaf and Petiole	Fruit		Stem	Leaf and Petiole	Fruit				
0	1.8	1.9	–	0.4	35	65	–				
28	4.3	4.7	–	3.8	20	80	–	0-28	0.13	2.74	–
42	5.0	4.9	3.8	20.0	37	61	2	28-42	1.15	5.94	0.03
56	4.3	5.0	3.4	49.0	18	52	30	42-56	2.08	2.91	1.03
70	3.7	4.5	3.0	93.2	16	40	44	56-70	3.16	1.69	1.86
84	2.3	3.1	2.6	90.5	15	34	51	70-84	–0.20	–0.02	0.34
98	2.4	3.2	2.3	122.7	23	37	40	84-98	2.31	0.57	0.27
112	2.2	3.4	2.5	135.6	25	35	40	98-112	0.92	0.18	0.34
LSD 5%	0.5	0.6	0.1	20.1	3	7	8		2.19	1.35	1.01

[z]KUR = Potassium uptake rate (kg/ha per day).

[y]SKACR = Specific K accumulation rate (mg K/g dry matter per day).

[x]KFUR = Fruit K uptake rate (kg/ha per day).

fruit at 84 days were 0.30, 0.20, and 0.33%, respectively. The highest P uptake rate was observed during 84-98 day period and the highest specific P accumulation rate was recorded 28-42 days after transplanting.

The accumulation of K by bell peppers increased with time and was recorded at 135.6 kg/ha at 112 days after transplanting (Table 5). The total amount of K in the plant was about the same as N and much more than P, Ca and Mg (Tables 3, 4, 6, 7). The lag in K uptake observed during the 70-84 day period might have been related to commercial fruit harvest. The K concentration in leaves and petioles, stems and fruit at 84 days was 3.1, 2.3, and 2.6% respectively. At 28 days, 80% of K was contained by leaves and petioles and 20% by stems. At 84 days, 34, 15, and 51% of total K was contained by leaves and petioles, stems, and fruit, respectively. The highest K uptake rate and the highest fruit K uptake rate occurred during 56-70 day period and the highest specific K accumulation rate was during the 28-42 day period.

The concentration of Ca in leaves and petioles, stems and fruit at 84 days was 2.2, 0.7 and 0.13%, respectively (Table 6). The Mg concentrations were 1.6% in leaves and petioles, 1.0% in stems, and 0.19% in fruit at 84 days (Table 7). At 28 days, 88% of Ca was contained by leaves and petioles and 12% by stems while 80 and 20% of Mg were contained by those portions. The highest Ca and Mg uptake rates (0.87 and 0.63 kg/ha/day) were measured during 84-98 and 56-70 day periods. The highest specific accumulation rates of Ca and Mg were recorded during 28-42 day period.

The high specific accumulation rate of all 5 elements that occurred early in the growth cycle was similar to the accumulation pattern observed in corn (10). Uptake of nutrients by peppers, which peaked during the 56-70 day interval continued at fairly high rates through the next 2 samplings, was apparently associated with fruit enlargement. Two other growth indices, mean crop growth rate and mean fruit growth rate, were highest in the 56-70 day period; but mean relative growth rate was largest in the 28-42 day interval. Still another parameter, mean net assimilation rate, was sustained at its highest level 28-70 days after transplanting. A relatively high mean net assimilation rate combined with a correspondingly low leaf area index might indicate that pepper plant populations could be markedly increased above the 48,000/ha used in this study.

The data presented here indicate that the growth processes were at a very high level by 28 days after transplanting and continued for at least 6 weeks. Thereafter, the growth rate declined somewhat. The high growth rate appeared to be sustained by fruit set and maturation.

Table 6. Ca concentration, total accumulation and distribution among above-ground portions, Ca uptake rate (CaUR), specific Ca accumulation rate (SCaACR), and fruit Ca uptake rate (CaFUR) by bell peppers.

Time after transplanting (days)	Ca concentration (% dry wt)			Total Ca (kg/ha)	Ca distribution (% of total)			Sampling interval (days)	CaUR[z]	SCaACR[y]	CaFUR[x]
	Stem	Leaf and Petiole	Fruit		Stem	Leaf and Petiole	Fruit				
0	1.4	2.4	–	0.4	25	75	–				
28	0.8	1.6	–	1.1	12	88	–	0-28	0.03	0.54	–
42	0.8	1.9	0.16	6.1	20	79	<1	28-42	0.35	1.78	<0.01
56	0.7	1.8	0.13	11.5	12	83	5	42-56	0.39	0.54	0.04
70	0.8	2.2	0.14	23.3	13	79	9	56.70	0.85	0.46	0.10
84	0.7	2.2	0.13	28.4	15	76	9	70-84	0.36	0.12	0.03
98	0.7	2.1	0.12	40.5	20	74	6	84-98	0.87	0.21	0.01
112	0.6	1.5	0.10	33.1	29	64	6	98-112	0.53	–0.10	–0.03
LSD 5%	0.07	0.3	.02	6.4	2	3	2		0.69	0.32	0.05

[z]CaUR = Calcium uptake rate (kg/ha per day).

[y]SCaACR = Specific Ca accumulation rate (mg Ca/g dry matter per day).

[x]CaFUR = Fruit Ca uptake rate (kg/ha per day).

Table 7. Mg concentration, total accumulation and distribution among above-ground portions, Mg uptake rate (MgUR), specific Mg accumulation rate (SMgACR), and fruit Mg uptake rate (MgFUR) by bell peppers.

Time after transplanting (days)	Mg concentration (% dry wt)			Total Mg (kg/ha)	Mg distribution (% of total)			Sampling interval (days)	MgUR[z]	SMgACR[y]	MgFUR[x]
	Stem	Leaf and Petiole	Fruit		Stem	Leaf and Petiole	Fruit				
0	0.6	0.6	–	0.1	38	62	–				
28	0.8	0.9	–	0.7	20	80	–	0-28	0.02	0.46	–
42	0.8	1.1	0.24	4.1	30	69	1	28-42	0.24	1.22	0.01
56	0.8	1.3	0.23	9.5	18	72	10	42-56	0.39	0.55	0.07
70	1.0	1.4	0.20	18.4	21	63	16	56-70	0.63	0.34	0.13
84	1.0	1.6	0.19	25.3	24	62	14	70-84	0.49	1.17	0.05
98	0.7	1.3	0.19	31.5	27	60	13	84-98	0.44	0.11	0.05
112	0.5	0.9	0.18	24.6	34	50	16	98-112	–0.49	–0.10	–0.02
LSD 5%	0.1	0.2	0.03	4.9	4	4	4		0.54	0.27	0.08

[z]MgUR = Magnesium uptake rate (kg/ha per day).

[y]SMgACR = Specific Mg accumulation rate (mg Mg/g dry matter per day).

[x]MgFUR = Fruit Mg uptake rate (kg/ha per day).

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J. Amer. Soc. Hort. Sci. 104(6):857–860. 1979.

Effect of Promalin on the Physical Characteristics of 'Delicious' Apples Grown in Two Geographic Locations[1]

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Additional index words. Malus domestica, fruit shape, growth regulator, L/D ratio, gibberellin A_4A_7, 6-benzylamino purine

Abstract. **A commercial formulation of N-(phenylmethyl) 1H-purin-6-amine plus gibberellin A_4A_7 (Promalin) was applied to 'Delicious' apples (*Malus domestica,* Borkh.) from 1975 to 1978 in 2 geographic locations at rates of 12.5 to 50 ppm. Promalin at 25 ppm increased fruit weight, length/diameter ratio (L/D), and percent "typey" fruit at both a cool mountain location and at a lower warm elevation. The effect on "typiness" in the warm growing area did not appear to be of commercial significance, but the increase in fruit weight did appear significant under these conditions. Response varied with strain. Addition of a spray adjuvant, Triton CS-7, at the lower elevation, did not improve response. Rates of 12.5 or 25 ppm applied at petal fall of the "king" blossom appeared to be equally effective under high temperature conditions conducive to oblate fruits.**

In Georgia, commercial apple production is confined to the northern mountain area and to Middle Georgia (lower Piedmont and upper Coastal Plain), which differ dramatically in their climate. In the latter region, apples are grown at elevations from 122 to 244 m (400 to 800 ft); in the mountains, elevation ranges from 366 to 670 m (1200 to 2200 ft). These differences result in considerable differences in growing season temperatures. Temperatures in the mountain region are similar to those found in more northern apple producing areas of the United States while conditions in the Middle Georgia area are less conducive to fruit typiness, since high temperatures are known to reduce fruit elongation (7, 12).

The shape of an apple is an important factor in marketing. 'Delicious' cultivars supposedly should be "typey" (have a high L/D ratio with prominent calyx lobes) for maximum consumer acceptance and value. High temperatures during the post bloom period generally result in an oblate fruit (5, 7).

Applications of gibberellins (1, 6, 8, 11, 13) and cytokinins (6, 8, 14) alone or in combination (8, 9, 14) increase both L/D ratio and prominence of the calyx lobes, resulting in a more typey fruit. Combined sprays of the gibberellin A_4A_7 and 6 benzylamino purine (BA) applied between the full bloom and petal fall are more effective than applications of either material alone (8, 9). Recently, a commercial formulation, Promalin, has increased L/D ratio and individual fruit weight, stimulated calyx lobing, and improved overall grade of 'Delicious' in a number of locations throughout the United States and Canada (2, 5).

Temperatures during early fruit development affect fruit shape (7). Most studies with Promalin have been conducted in regions where mean temperatures during the 20 to 30 day post bloom period are about 10 to 14°C. However, temperatures in the commercial apple producing region in Middle Georgia are commonly 15 to 19° during this period, resulting in an oblate apple, particularly in 'Delicious'. Climatic influences may extend well beyond the brief period after bloom (12).

The purpose of this study was to determine the effect of Promalin on 'Delicious' apples grown in climatically different areas of Georgia.

Materials and Methods

Abbott Laboratories'[3] formulation of Promalin (formerly ABG 3001) was used throughout this 4-year study. Table 1 gives locations, rates, and times of application for the years 1975 through 1978. Treatment rates and times of application were altered as more information became available (10). All treatments were applied to whole trees in randomized complete blocks with 10 to 50 replications per treatment. In 1975 ('Top-red Delicious') and 1978 ('Sturdeespur Delicious' only) treatments were applied to runoff with a low pressure compression sprayer (H. D. Hudson Company, Chicago, 60611) using a Tee-Jet TX2 cone nozzle. The remaining sprays were applied with a Bean 200 TR air blast sprayer using #5 nozzles set to deliver 1402 liters/ha (150 gpa). Triton CS-7 was used as a spray adjuvant in 1978 at 625 ppm (0.62 ml/liters or ½ pt/100 gal) and 1250 ppm, respectively. Spray adjuvants were not used in 1975, 1976, or 1977. A sample of 25 fruits was collected at random from each of 10 randomly selected whole trees within the treated plot for fruit size determinations at harvest. The following data were obtained on individual fruits: weight, length, diameter, length/diameter (L/D) ratio, calyx lobe formation (1-5 scale, no lobing to prominent points, 1975 and 1976 only), and typiness [typey (conic shape, prominent calyx lobes), non-typey, or partially typey as rated visually by 2 independent judges]. Fruit body length was determined by measuring the fruit length that remained after the calyx end of fruits had been removed to expose a solid disc of apple flesh tissue. Calyx length was computed by subtracting body length from overall fruit length (9). Fruit length and diameter were recorded with a direct reading dial micrometer calibrated

[1]Received for publication May 9, 1979.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

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