Variation in Carotene Content of Sweet Potatoes

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Composite samples of sweet potatoes—averages of 10 replicates of five roots each—taken from different sections of a 7500-square-foot area were found to vary, within a variety, as much as 45% in total carotenoids and 145% in carotene—highest over lowest sample. Sweet potatoes from the same field averaged more than twice as much carotene one season as the next. Those grown with limited soil moisture were higher in carotene than those grown with abundant moisture. Individual roots from the same plant varied in carotene, as much as 47% in Orange Little Stem and 82% in Yellow Jersey. High-yielding plants from a plot averaged significantly higher in carotene content per unit weight than the plot average. The carotene content appears to be more closely associated with rate of growth of the root than with the size attained. Carotene content at harvest was not a determining factor in amount of increase during storage, but in a season when all lots were relatively high in carotene at harvest, the increase during storage was also high. The moisture content of sweet potato samples varied up to 3% within a season; differences between seasons were sometimes greater, but the highest moisture content was not necessarily in the season or area of highest soil moisture.

The yellow, orange, or salmon color in the flesh of sweet potatoes is due to carotenoid pigments. β-Carotene, the principal pigment in varieties having deeply colored flesh, is the precursor of vitamin A, and, therefore, the most important pigment from the nutritional standpoint in all varieties. Sweet potatoes vary widely in flesh color, not only between varieties, but also within varieties. Total carotenoid pigments, as reported in 1946, ranged from 2.10 to 6.95 mg. per 100 grams of tissue and carotene from 1.46 to 6.39 mg. per 100 grams in 27 individual Porto Rico sweet potatoes (*3*).

According to data presented later (*5*), sweet potatoes increase in carotene and total carotenoids from mid-August until late September or early October and then decrease after frost kills the vines. While the general trend was fairly consistent, there were individual fluctuations between sampling dates—some statistically highly significant—for which no definite cause could be ascribed. In general, changes in carotene content took place rather gradually both in the field and during storage. This might suggest that the divergent samples were not truly representative of the population average. In 1953, workers at seven southern agricultural experiment stations (*6*) reported on results from roots harvested beginning in mid-September and ending before frost. They found wide variations in carotene content, but, as their results indicated that the changes were as likely to be negative as positive during this period, they concluded that the direction of change was not predictable. These workers also found wide differences between locations and seasons and concluded "that location effects had more influence on carotene content than year to year effects within one location."

Because of the importance of sweet potatoes as a food crop, variation in carotene content is of considerable interest and importance, not only to the research worker, but to all having to do with the nutritive value of foods. The present work supplies additional information on variations in carotene content of sweet potatoes and on some of the conditions pertaining thereto. Two varieties were grown in a single location and harvested during a 3-week period in 2 consecutive years; also, individual roots from the same plant and individual plants from the same area were studied in a third season. The effect of rate of plant growth on the carotene content of the fleshy roots, of size of the root on the carotene content, and of the carotene content at harvest on the subsequent accumulation during storage was also studied. Some data on the variations in ascorbic acid and in moisture were obtained.

Materials and Methods

Orange Little Stem and Yellow Jersey sweet potatoes were grown in 50 × 150 foot plots on Chillum sandy loam at the Plant Industry Station, Beltsville, Md., in 1951 and 1952, and again in 1955. These varieties were selected because of their tendency to form many miniature sweet potatoes in a relatively close cluster early in the season. These fleshy roots increase in size as the season progresses, but usually at different rates. Many varieties tend to prolong the period of formation of the fleshy roots and to distribute them over a wider area and at different levels in the soil. Sweet potatoes of the first type are subjected to more uniform soil and environmental conditions and might therefore be expected to vary less in carotene than those of the second type.

The sweet potatoes, grown according to standard procedures, were harvested between September 10 and October 2. In some cases, two or more samples were harvested on the same date and others 1 or more days apart. The plots were subdivided and the samples were taken from different subsections. During the second season, the last four samples were taken from the same subsections as the first four and in the same order—i.e., 1st and 5th, 2nd and 6th, 3rd and 7th, and 4th and 8th came from

Table I. Variations in Carotene, Total Carotenoid, and Moisture Contents of Sweet Potatoes at Harvest and after Storage

			Carotene			Total Carotenoids			Moisture	
Variety	Date Harvested	Days in Storage	At harvest mg./100 g.	After storage, mg./100 g.	Increase, %	At harvest, mg./100 g.	After storage, mg./100 g.	Increase, %	At harvest, %	After storage, %
Orange Little Stem	9/10/51	161	5.37	7.55	41	6.04	8.33	38	75.3	78.0
	9/12/51	153	6.02	6.65	10	6.48	7.75	20	77.9	79.8
	9/12/51	183	4.92	6.26	27	5.60	7.16	28	78.0	79.8
	9/19/51	161	5.70	8.07	42	6.35	8.77	38	77.6	78.5
	9/27/51	155	6.17	7.55	22	7.09	8.40	18	76.5	78.6
	9/28/51	156	7.19	8.39	17	8.14	9.20	13	76.1	78.9
	10/2/51	141	6.50	7.37	13	8.13	8.26	2	77.1	77.9
Average		159	5.981	7.406	24[a]	6.833	8.267	21[a]	76.93	78.79
Least significant difference										
1%			0.658	0.625	...	0.582	0.675	...	1.44	2.65
5%			0.491	0.469	...	0.437	0.507	...	0.97	1.79
Orange Little Stem	9/10/52	148	2.53	2.54	0	3.17	3.17	0	71.7	71.8
	9/15/52	156	2.85	3.33	17	3.56	3.96	11	71.8	72.2
	9/17/52	160	2.64	3.26	24	3.48	3.91	12	72.6	73.1
	9/18/52	162	2.36	2.74	16	2.97	3.39	14	73.5	73.1
	9/20/52	139	2.78	3.07	10	3.48	3.75	8	71.5	71.7
	9/25/52	147	2.80	3.04	9	3.56	3.66	3	72.3	72.9
	9/28/52	150	3.19	3.52	10	3.85	4.18	8	72.0	72.2
	9/30/52	150	2.53	3.00	19	3.21	3.70	15	72.6	72.9
Average		152	2.710	3.062	13[a]	3.410	3.715	9[a]	72.25	72.50
Least significant difference										
1%			0.262	0.369	...	0.316	0.380	...	0.77	1.33
5%			0.198	0.278	...	0.238	0.286	...	0.58	1.00
Yellow Jersey	9/10/51	157	0.11	0.62	464	0.57	1.47	158	72.9	74.4
	9/19/51	159	0.17	0.66	288	0.68	1.53	125	72.1	73.7
	9/19/51	164	0.15	0.65	333	0.67	1.65	146	71.3	74.3
	9/19/51	175	0.15	0.89	493	0.74	1.92	159	70.8	73.6
	9/28/51	160	0.27	0.57	111	0.82	1.45	77	70.9	73.2
	10/2/51	139	0.27	0.67	148	0.81	1.58	95	71.1	73.3
Average		159	0.187	0.677	262[a]	0.715	1.600	124[a]	71.53	73.72
Least significant difference										
1%			0.018	0.114	...	0.047	0.133	...	1.82	1.22
5%			0.014	0.085	...	0.036	0.100	...	1.20	0.80
Yellow Jersey	9/10/52	219	0.10	0.37	270	0.52	1.06	104	72.7	73.1
	9/15/52	219	0.07	0.44	529	0.48	1.08	125	74.4	73.0
	9/17/52	218	0.06	0.33	450	0.41	0.98	139	75.4	74.5
	9/20/52	219	0.08	0.31	288	0.49	0.97	98	74.6	74.4
	9/22/52	207	0.08	0.46	475	0.51	1.18	131	73.2	72.4
	9/26/52	208	0.07	0.34	386	0.44	0.94	114	74.6	74.7
	9/29/52	207	0.08	0.40	400	0.44	1.05	139	75.7	75.5
	10/1/52	209	0.11	0.37	236	0.48	1.05	119	75.2	75.6
Average		213	0.081	0.378	367[a]	0.471	1.039	121[a]	74.46	74.15
Least significant difference										
1%			0.016	0.095	...	0.036	0.133	...	1.00	1.00
5%			0.012	0.071	...	0.027	0.100	...	0.76	0.76

[a] Percentage increase in averages.

the same subsections but were harvested on different dates.

In 1955, the sweet potatoes were grown under uniform conditions until root enlargement begins—late July in this area. Manipulative treatments to promote or retard growth of the vines and to retard the synthesis of reserve food materials were then started and continued until harvest. The treatments were as follows:

Soil was irrigated weekly, unless 0.1 inch of rain fell during the preceding 7 days (to promote vigorous vine growth).

Control vines were undisturbed.

Vines were lifted 10 days before harvest to break adventitious roots along the surface (to retard growth by reducing moisture intake shortly before harvest).

Vines were lifted weekly and restricted to approximately $^1/_3$ normal area (to retard growth by reducing moisture intake and retard synthesis of reserve food material by reducing area for leaf exposure).

Vines of individual plants were lifted, folded, and rolled into a 3-foot bundle at weekly intervals (to retard growth by reducing moisture intake and retard synthesis of reserve food material by reducing area for leaf exposure and making it necessary for plant to reorient its leaves each week).

Sweet potatoes from these plants were used in the studies on variations between individual roots from the same plant, between means of individual plants from the same area, and on effects of rate of plant growth on the carotene content of the fleshy roots.

The methods of analysis and general procedures were the same as previously described (*4*). The roots were washed at harvest to remove adhering soil and then weighed individually; the weight in grams was recorded on each root with an indelible pencil. Roots for storage were cured at 85° F. and 85% relative humidity for 8 days and then stored at 60° F. They were reweighed at time of analysis. Comparable samples of 50 to 75 roots each were used, and chemical analyses were made at harvest and after storage. The carotene and total carotenoids were determined by the method of Wall and Kelley (*13*). The method of Loeffler and Ponting (*8*) was used for determining ascorbic acid. Unless otherwise noted, each analytical sample consisted of 10 replicates of five roots each, and each replicate was analyzed in duplicate. The results of the duplicates were averaged, and the value reported is the average of the 10 replicates calculated back to the weight at harvest. Moisture samples were taken from two of the 10 replicates during the first season and from each of the 10 replicates during the second and third seasons.

Table II. Climatological Data, Station No. 2, Beltsville, Md.

Month	Average Temp., ° F.			Rainfall, Inches			Sunshine,[a] % of Possible		
	1951	1952	1955	1951	1952	1955	1951	1952	1955
June	69.7	72.5	65.8	10.32	2.93	5.12	57	75	59
July	74.5	76.3	78.8	1.78	2.60	0.74	77	78	61
Aug.	72.3	72.9	76.4	1.53	4.00	11.74	77	60	48
Sept.	66.4	64.9	66.6	2.47	5.19	0.87	60	77	54

[a] Sunshine data for Washington National Airport, Washington, D. C.

Results and Discussion

Variations in Carotene Content within and between Seasons. The carotene, total carotenoid, and moisture contents at harvest and after storage of sweet potatoes, harvested at different times in 1951 and 1952, are shown in Table I. In the first season, during the harvest period of 3 weeks, the carotene content of Orange Little Stem sweet potatoes varied from 17% below to 20% above the mean of 5.98 mg. Differences between samples of 8.2 and 11.2% were statistically significant at the 5 and the 1% level, respectively. During the second season, the carotene content ranged from 12% below to 17% above the mean of 2.71 mg. Differences for significance this year were 7.3 and 9.7%, respectively, at the 5 and the 1% level.

In Yellow Jersey, during the first season, the carotene content ranged from 41% below to 44% above the mean of 0.187 mg. per 100 grams. Differences required for significance at the 5 and the 1% level were 7.5 and 9.6%, respectively. In the second season, with an average of 0.081 mg. per 100 grams, the content ranged from 26% below to 36% above, 14.9 and 19.8% being required for significance at the 5 and the 1% level, respectively.

During the first season the Orange Little Stem variety averaged 5.98 mg. per 100 grams of tissue against 2.71 mg. in the second season, or 2.2 times as much. Comparable values for Yellow Jersey were 0.187 mg. and 0.081 mg., or 2.3 times as much. In the second season, the seed stock of Orange Little Stem was from a different source than the first, but the Yellow Jersey was from the same stock as in the preceding year. As the differences between the two varieties in the 2 years were practically the same, the different seed source was thought not to be a major factor in the differences for Orange Little Stem. The pattern for total carotenoids is essentially the same as for carotene.

Temperature is a primary factor in influencing the carotene content of sweet potatoes in storage (*4*), but does not appear to be the reason for the difference in these samples at time of harvest. Samples harvested on the same date sometimes showed wider differences than samples harvested several days or weeks apart. This would tend to minimize climatic conditions as a major factor for local differences between samples in a single season. A study of climatological data (*12*) (Table II), reveals that there were no outstanding differences in temperature during the two seasons. The percentage of the possible sunshine was slightly higher in the second season. Total precipitation amounted to 16.10 inches in the 1951 season and 14.72 inches in 1952.

The period of root enlargement, and probably the critical period in determining the carotene content is primarily August and September in this area. For this period the average temperature and percentage of possible sunshine were almost the same for the 2 years, but the rainfall was greatly different. In the first season, rain occurred on 12 days —a total of 4.00 inches—approximately half normal for the period, compared with 26 days and 9.9 inches, somewhat above normal, in the second season. Yield records were not taken, but data from sweet potato investigations by the Agricultural Research Service indicate that, in general, the yield of sweet potatoes at Beltsville was approximately one third greater in the wet year than in the dry.

Variations in Carotene Content within and between Plants. Data in Table III show the variations in weight, carotene, and total carotenoids in individual roots from the same plant and in the means of 10 different plants of two varieties. Orange Little Stem sweet potatoes from the same plant varied as much as 47% in carotene and 49% in total carotenoids, and Yellow Jersey as much as 82 and 51%, respectively. Means of all roots from single plants varied from other plants in the area by as much as 32% in carotene and 27%

Table III. Variations in Weight, Carotene, and Total Carotenoids of Individual Sweet Potatoes from Same Plant and in Means of Individual Plants

Variety and Plant No.	No. of Roots	Wt. Mean, grams	Wt. Max./min. × 100	Carotene Mean, mg./100 g.	Carotene Max./min. × 100 %	Total Carotenoids Mean, mg./100 g.	Total Carotenoids Max./min. × 100	Coefficient of Correlation between Weight and Total Carotenoids
Orange Little Stem								
1	6	87	163	5.03	129	5.51	126	−0.47
2	6	130	388	4.74	119	5.39	122	+0.29
3	6	90	178	5.01	124	5.57	121	+0.86[a]
4	6	88	197	6.25	112	6.88	111	+0.63
5	6	102	229	5.58	121	6.06	119	+0.05
6	7	125	265	5.21	137	5.67	136	−0.31
7	7	134	365	5.81	126	6.29	129	+0.05
8	7	132	262	5.40	147	6.14	149	−0.72
9	6	141	263	5.29	105	6.05	121	+0.34
10	5	177	193	4.83	116	5.42	115	+0.01
1–10	62	745[b]	180[b]	5.31[b]	132[b]	5.90[b]	127[b]	−0.11
Yellow Jersey								
1	5	129	249	0.171	133	0.694	119	+0.78
2	5	232	409	0.163	124	0.687	113	−0.68
3	9	174	363	0.155	156	0.646	151	−0.31
4	6	138	329	0.194	155	0.742	117	+0.23
5	7	119	284	0.251	148	0.844	129	−0.67
6	8	120	325	0.197	130	0.757	134	+0.56
7	6	146	415	0.221	182	0.757	123	−0.33
8	5	140	224	0.286	122	0.819	127	−0.94[a]
9	7	119	300	0.274	126	0.902	120	−0.36
10	5	137	232	0.218	166	0.731	136	−0.29
1–10	63	909[b]	243[b]	0.213[b]	185[b]	0.758[b]	140[b]	−0.33[c]

[a] Significant at 5% level.
[b] Per plant basis.
[c] Significant at 1% level.

in total carotenoids in Orange Little Stem and 85 and 40%, respectively, in Yellow Jersey.

Carotene Content of High and Low Yielding Plants. The determining factor in the selection of plants for use in the study of variation in roots from the same plant was the number of marketable roots produced. A large number of roots was desired for each plant tested. As the varieties used seldom produce "jumbo" roots, yield is more closely correlated with the number of marketable roots than with the size of the roots. Consequently, the plants selected were from the highest yielding plants in the plot. While the average carotene content was not directly proportional to the yield per plant, the sweet potatoes from these plants averaged significantly higher in carotene than the plot average. High-yielding plants thus tend to produce roots higher in carotene (provitamin A) than low-yielding plants in the same plot.

Rate of Vine Growth and Carotene Content. Sweet potatoes from vines growing slowly at harvest are higher in carotene than those from vines growing vigorously. In a season when soil moisture was low, sweet potatoes with a very high carotene content were produced when the vines were lifted and confined to a smaller area, but the yield was low.

Lifting the vines to break adventitious roots thereon was once believed to reduce vine growth, hasten development of the storage roots, and increase the yield. Starnes (*10*) reported a decrease in yield from lifting the vines in a relatively dry season, but suggested that it might be beneficial in a wet year. Abundant soil moisture tends to negate the effects observed in a dry season.

Effect of Size of Root on Total Carotenoid Content. The increase in carotene and total carotenoids as the season advances, reported in an earlier paper (*5*), is not primarily dependent upon the larger size of the roots later in the season. This is shown in Table III where the coefficients of correlation (r) between size (weight) of root and total carotenoids are given for two varieties, both for individual roots of individual plants and of all the roots from 10 plants. In individual plants and, with the small number of degrees of freedom, in only one plant of each variety was there a significant correlation (5% level). In the majority of cases r is positive in Orange Little Stem and negative in Yellow Jersey. When all roots from 10 plants and the greater number of degrees of freedom were used, r equaled -0.11 (not significant) in Orange Little Stem and -0.33 (statistically significant at the 1% level) in Yellow Jersey.

The fact that r is negative when roots from different plants are included may be related to slower growth in the smaller roots. (These varieties tend to form many miniature sweet potatoes early in the season and these increase in size as the season progresses.) This is in agreement with the observation that reduced vine growth results in roots higher in carotenoids and that a dry season (1951) resulted in a higher carotenoid content than a wet season (1952). If this is generally true—i.e., if slow growth is more favorable to a high carotenoid content—one may assume that the sweet potatoes with light-colored flesh in a lot are relatively rapidly growing ones. Size of root would depend on both the period and the rate of growth. If a root were large because of a long, slow growth period, the carotenoid content would tend to be high, but if large because of rapid growth over a short period the carotenoids would tend to be low.

The higher carotenoid content of the sweet potatoes from the higher yielding plants used in the studies of variation between individual roots from the same plants might also be explained by this hypothesis. These plants averaged a greater number of marketable sweet potatoes per plant than did the plot average. Consequently, the food materials synthesized by these plants for storage would need to be distributed to a larger number of growing sweet potatoes. Growth of the individual roots would tend to be slower and thus conducive to a higher carotenoid content.

This hypothesis of slow growth–high carotenoid content is in agreement with results reported by other workers. Edmond and Sefick (*2*) studied the growth of Porto Rico sweet potatoes in sand culture. They found that plants receiving a complete nutrient solution, or one deficient in either phosphorus, potassium, calcium, or magnesium, produced more top growth than one deficient in nitrogen. The potassium-deficient plants gave the lowest yield of sweet potatoes—less than 100 grams per plant. With this exception, the nitrogen deficient plants were lowest in yield, but the flesh was pink in color (high carotenoids), whereas the flesh from the other plants was light pink or creamy white in color (lower carotenoids). Speirs and coworkers (*9*) studied the effect of various fertilizer combinations on the Porto Rico variety at both Georgia and North Carolina Agricultural Experiment Stations for two seasons. They found no significant differences in either carotene content or in yield from the different treatments. When manipulative treatments showed no effect on the yield (1955), there was little difference in the carotene content, but in other years when the yield was reduced there was an increase in carotene. Anderson and associates (*1*) reported more jumbo sweet potatoes (indicating more rapid growth of the roots) and lower carotene content as the spacings between the hills were increased.

Effect of Carotene Content at Harvest on Its Subsequent Accumulation during Storage. High carotene content at harvest did not impede synthesis during storage (Table I). The average increase in actual carotene in the 1951 Orange Little Stem roots was four times as much during storage as in the 1952 roots with about half as much carotene content at harvest. Expressed as a percentage of that present at harvest, increases were 24 and 13, respectively, in the two seasons. In Yellow Jersey, the increase during storage in the first season was 1.6 times as much actual carotene as in the second season, but as percentages of that present at harvest the increases were 262 and 366, the higher value being for the second season. However, the storage period of the Yellow Jersey, a long-keeping variety, averaged 159 days in the first season and 213 days in the second, or 34% longer in the second season. After adjustment for the shorter time in storage the first season, the values would be 2.2 times as much actual carotene in the first season and about the same percentage increase in the 2 years. Intraseasonally, the carotenoid concentration at harvest apparently had little effect on the increase during storage, as the coefficients of correlation were not statistically significant for either carotene or total carotenoids in either year.

Carotene Content on Fresh-Weight and Dry-Weight Basis. The moisture content is in inverse ratio to total solids. Consequently, the carotene values will be somewhat different if calculated on a dry-weight instead of a fresh-weight basis. However, this does not greatly affect the amount of variation. In Table IV the mean carotene contents at harvest for 1951 and 1952 calculated on both bases are shown together with the percentage variation for the 2 years. The results are comparable both intra- and interseasonally.

Variations in Ascorbic Acid. Ascorbic acid varies widely in many horticultural crops. As a basis for comparing the variation in carotene with the variation in ascorbic acid, the ascorbic acid content of individual roots from the same plant and in the mean of all roots from single plants of two varieties are shown in Table V, along with coefficients of correlation between size of root and ascorbic acid content. These results indicate that, on a percentage basis, variations in carotene content are comparable in magnitude to those in ascorbic acid. What appears to be a slight positive correlation between size of roots and ascorbic acid content in single plants is lost when all roots from the 10 plants are considered together.

Variations in Moisture Content. The moisture content of sweet potatoes also varied at the time of harvest (Table

Table IV. Variations in Carotene Content of Sweet Potatoes Calculated on Fresh-Weight and on Dry-Weight Basis

Variety and Year	No. of Samples	Fresh-Weight Basis: Carotene mean, mg./100 g.	Fresh-Weight Basis: Max./min. × 100 %	Dry-Weight Basis: Carotene mean, mg./100 g.	Dry-Weight Basis: Max./min. × 100 %
Orange Little Stem					
1951	7	5.981	134	25.930	138
1952	8	2.710	135	9.758	128
Yellow Jersey					
1951	6	0.187	245	0.650	232
1952	8	0.081	183	0.316	183

I). Within a variety, the differences were usually less than 3% in a single season, but some of them were statistically highly significant. Differences between seasonal averages were sometimes greater than 3%, but the moisture content of the roots was not always higher in the season of greater rainfall. In the 1955 studies, plants without irrigation or adventitious roots along the vines produced sweet potatoes higher in moisture than irrigated plants with unrestricted root growth. In dry seasons and when the vines are disturbed, yield is reduced apparently through decreased synthesis and storage of dry matter. Perhaps these roots may better be considered as low in solids, and the higher moisture only incidental to the low dry matter. As these differences in moisture content had no noticeable effect on the storage behavior of the sweet potatoes, such differences are of little physiological importance.

Normal-appearing plants, growing under as nearly uniform conditions as it is feasible to provide, will vary in yield from nothing to 2, 3, 4, or even more pounds per plant. Steinbauer, Hoffman, and Edmond (*11*) were unable to associate yield of individual plants with mother roots, mode of propagation, or any other recognizable conditions. Yield, as well as the carotene content, thus appears to be dependent upon the composite effect of all the factors entering into the growth of the plant. Harter and Whitney (7) reported the minimum temperature for growth of sweet potato plants to be somewhere between 59° and 68° F. At 50° F., the plants turned a "yellow, sickly color" in 3 or 4 days and gradually died. Whether shorter periods at these, or lower, temperatures permanently affect the metabolism of the plant, or whether the plants may be more sensitive to environmental conditions at certain stages of growth than at others is unknown. As there is no known method of preventing or appreciably reducing the variations in carotene content of sweet potatoes grown under usual conditions, extreme care should be taken to secure adequate and representative samples in any study involving changes in the carotene content.

Table V. Variations in Weight and Ascorbic Acid Content of Individual Sweet Potatoes from Same Plant and in Means of Individual Plants

Variety and Plant No.	No. of Roots	Weight: Mean, Grams	Weight: Max./min. × 100 %	Ascorbic Acid: Mean, mg./100 g.	Ascorbic Acid: Max./min. × 100 %	Coefficient of Correlation between Weight and Ascorbic Acid
Orange Little Stem						
1	6	152	289	44.3	139	+0.24
2	6	109	235	53.9	119	−0.13
3	8	120	366	44.2	138	+0.62
4	7	129	378	56.8	142	+0.79[a]
5	7	95	177	44.0	116	+0.36
6	5	154	402	55.3	154	+0.69
7	5	106	203	44.4	142	+0.96[b]
8	5	112	276	51.3	115	−0.38
9	6	109	293	50.4	183	+0.53
10	5	101	242	44.8	173	+0.57
1–10	60	711[c]	190[c]	48.9[c]	129[c]	+0.02
Yellow Jersey						
1	8	169	677	36.1	164	+0.54
2	10	123	243	39.0	143	+0.20
3	5	109	206	39.5	128	−0.67
4	5	140	237	34.2	147	−0.35
5	5	142	290	39.2	122	−0.40
6	7	81	161	39.8	117	−0.31
7	5	138	209	32.9	130	+0.93[b]
8	5	124	214	32.2	115	+0.38
9	5	110	216	34.4	109	+0.19
10	6	102	161	41.0	138	+0.55
1–10	61	758[c]	248[c]	36.8[c]	127[c]	+0.06

[a] Significant at 5% level.
[b] Significant at 1% level.
[c] Per plant basis.

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