AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the

United States Department of Agriculture and Cooperating Agencies

Volume XI | JANUARY 1959 | Number 1

Forecasting Date of Volume Movement of Colorado Peaches

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As a means of forecasting probable maturity dates of standard Elberta peaches, the growers in Mesa County, Colo., in past seasons have had only the 126-day average elapsed time from full bloom to the date of shipment of the first car. Methods for forecasting maturity dates more accurately than those formerly used were developed by the authors and are described in this paper. Empirical methods, utilizing daily maximum temperatures from full bloom until June 30, gave calculations accurate within plus or minus 3 days in 25 of 26 years, relative to the first 25-car day, and in all 26 years relative to the first carlot equivalent. The new methods appear to offer a means to enhance harvesting and marketing operations, effect financial savings, and reduce waste.

AN ACCURATE FORECAST of the beginning of volume movement of standard Elberta peaches from Mesa County, Colo., could effect a more orderly and timely arrival of picking and packing labor, inspectors, buyers, trucks, and refrigerator cars than the industry has had, and it would enhance marketing procedures generally.

During the 1957 harvest season, for example, Mesa County was plagued for many days with between 3,000 and 4,000 idle migrant workers. Occasionally, under such conditions, enough of the labor force to cause concern moves on in search of immediate income. In other years, peaches are ready before the labor supply is adequate. The aggregate cost of retaining idle inspectors and buyers and the revenue loss to idle transportation facilities justify a serious effort to develop a relatively accurate method of forecasting volume peach movement early enough in the season to avoid most of these problems. For practical reasons, July 1 is regarded as the latest completely useful date for such a forecast.

The method of estimating harvest dates relied upon by the industry in the past has utilized the long-term average of days elapsed from full bloom to shipment of the first carlot equivalent of standard Elbertas. The average, 126 days, falls within extremes of 119 and 131—historical errors of 7 and 5 days, respectively. Reduction of this error to 3 days or less was the objective of our study. For clarity and want of a better term the prevailing method is referred to as the "industry method."

The study that was the basis for this report was initiated by the senior author 2 years ago. He undertook the study in the hope that weather data might yield a more reliable method of forecasting the beginning of volume peach shipments. Early efforts were confined to monthly average data and deviations thereof from normal. The results were inconclusive, but they suggested the probability that daily data in some form would produce a reliable method.

Maximum Temperature the Yardstick

The daily maximum temperature, a recognized yardstick of photosynthesis, was judged to be the criterion most likely to explain differences in elapsed time from full bloom to harvest. Optimum temperatures for peach development range roughly from 54 to 72 degrees Fahrenheit, although at ripening the range narrows toward the upper limit with little development of consequence below 68 degrees.[1]

Fortunately for our purpose, a maximum temperature below 75 degrees rarely is reached in July and August. Maxima range rather consistently between 80 and near 100, and usually are above the threshold value during all daylight hours. It is this climatic feature that facilitates development of a forecasting procedure fitting the specifications of earliness (no later than July 1) and of suitable accuracy.

For all practical purposes then, the period from July 1 to harvest can be considered analogous from year to year. Temperature requirements are met every day alike, whether the maximum is 80 or 100. Hence, if temperature is a reliable measure, any difference of consequence in elapsed time from full bloom to maturity should be detectable in maximum temperatures experienced before July 1. This appears to be borne out, yet it is contrary to the consensus of the industry, which tends to hold that midsummer weather has the greatest influence on harvest dates.

Many empirical methods that utilize variations of accumulated heat units were sampled. The most satisfactory methods—the ones described here—use a reversal of this procedure, whereby a base number of days to maturity is established, to which noncreditable days are added.

Two different base numbers of days were utilized, one the least number of days ever experienced from full bloom to shipment of the first carlot equivalent, and the other the least number of days ever experienced from full bloom to the first day shipments reach or exceed 25 cars per day. These bases were 119 and 123 days, respectively. It should be pointed out that these figures represent years virtually void of cool weather in the postbloom period.

Noncreditable days are those before July 1 when maximum temperature fails to rise into, or above the optimum range of 54 to 72 degrees. Obviously, not all temperatures in the optimum range are equally effective. Peaches would be expected to develop more slowly at the lower limits of this range than at the upper. Arbitrary values, realized from trial and error, were assigned to certain maximum temperature intervals within the optimum range, rating their relative effectiveness. Specifically, maxima below 54 degrees equal one full noncreditable day; 54 to 60 degrees equal two-thirds of a day; 61 to 65 degrees equal a third of a day; and all maxima above 65 degrees are assumed to be fully and equally creditable.

In calculating the number of days from full bloom to shipment of the first carlot equivalent, if 3 days failed to reach 54 degrees, the fruit-development period would be lengthened by 3 days; in other words, 3 days would be added to the base figure of 119, making 122 days. Should 3 days range between 54 and 60 degrees, 2 additional days would be added, making 124; and should 3 days range between 61 and 65 degrees, one more day would be added, bringing the total to 125 days. Thus 125 days would be expected from full bloom to shipment of the first carlot equivalent.

Further Refinement Necessitated

Year-to-year variations in the date of full bloom, varying historically from March 27 to April 27, necessitated further refinement to take account of the fact that years of unusually early bloom invariably required more than the average number of days to maturity. An explanation may lie in the shorter days and the frequently greater diurnal fluctuations in temperature experienced before the average date of full bloom, when maximum temperatures would be expected to remain in the optimum range for shorter intervals.

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[1] Gardner, V. R., Bradford, F. C., and Hooker, H. D. THE FUNDAMENTALS OF FRUIT PRODUCTION. McGraw-Hill, New York, 1939. Pp. 267–283.

TABLE 1.—*Comparison of authors' method, industry method, and observed number of days from full bloom to first carlot equivalent of standard Elberta peaches, Mesa County, Colo.*

Year	Observed days to first car X_o	Adjustments: Noncreditable days X_1	Adjustments: Earliness X_2	119-day base to first car plus X_1 and X_2 X_{oc}	Difference $X_{oc}-X_o$	Industry estimate (mean of X_o) X^1_{oc}	Difference $X^1_{oc}-X_o$
1931	126	7	0	126	0	126	0
1932	126	7	0	126	0	126	0
1933 [1]	---	---	---	---	---	---	---
1934	129	5	5	129	0	126	−3
1935	129	9	0	128	−1	126	−3
1936	121	4	0	123	2	126	5
1937	125	4	0	123	−2	126	1
1938	124	6	0	125	1	126	2
1939	119	0	0	119	0	126	7
1940	126	6	2	127	1	126	0
1941	129	8	0	127	−2	126	−3
1942	131	11	0	130	−1	126	−5
1943	130	8	2	129	−1	126	−4
1944	125	8	0	127	2	126	1
1945	127	5	0	124	−3	126	−1
1946	124	2	0	121	−3	126	2
1947	130	8	1	128	−2	126	−4
1948	120	4	0	123	3	126	6
1949	123	2	0	121	−2	126	3
1950	127	8	0	127	0	126	−1
1951	123	4	0	123	0	126	3
1952	121	3	0	122	1	126	5
1953	126	9	0	128	2	126	0
1954	127	5	2	126	−1	126	−1
1955	122	4	0	123	1	126	4
1956	124	4	1	124	0	126	2
1957	130	14	0	133	3	126	−4

[1] Data missing.

X_o: Observed number of days from full bloom to first carlot equivalent.

X_1: Number of days discounted for low maximum temperature. Scored 1 day if maximum below 54 degrees; ⅔ of a day if 54 to 60; ⅓ of a day if 61 to 65. Surplus fractions omitted, i. e., 2⅔ equals 2.

X_2: Earliness adjustment, ¼ of a day added for each day full bloom occurred before the April 16 average. Surplus fractions omitted, i. e., 2¾ equals 2.

X_{oc}: Historical average number of days from full bloom to first carlot equivalent.

An adjustment factor for early bloom therefore was incorporated by adding a fourth of a day for each day by which full bloom occurred earlier than the April 16 average. In the example described above, if full bloom occurred on April 12, 4 days earlier than average, one full day would be added to the 125 already accumulated, and 126 would be the forecast number of days from full bloom to the first carlot equivalent.

Early trials assumed that a similar but reversed adjustment would be necessary to take account of late bloom. It was indicated, however, that the factors making such adjustment for early bloom necessary tend to become less important as the season advances, as no clear association of late bloom with fewer than average days to maturity was established.

Old and New Methods Compared

The two methods, one forecasting the first carlot equivalent, the other the first 25-car day, were compared with the industry's forecasting methods. The years 1931 through 1957 were used—1933 was omitted for lack of data. It was deemed advisable to consider forecasting on both bases because, while the industry appears to be most concerned with the first carlot equivalent shipped, the date thereof can be influenced by a number of personal or individual factors other than maturity. The first 25-car day is deemed to be more reliable as a measure of readiness for harvest as, of necessity, it represents the composite maturity judgment of a number of growers.

TABLE 2.—*Comparison of authors' method, industry method, and observed number of days from full bloom to first 25-car day of standard Elberta peaches, Mesa County, Colo.*

Year	Observed days to first car X_o	Adjustments: Noncreditable days X_1	Adjustments: Earliness X_2	123-day base to first car plus X_1 and X_2 X_{oc}	Difference $X_{oc}-X_o$	Industry estimate (mean of X_o) X^1_{oc}	Difference $X^1_{oc}-X_o$
1931	130	7	0	130	0	130	0
1932	131	7	0	130	−1	130	−1
1933 [1]							
1934	135	5	5	133	−2	130	−5
1935	134	9	0	132	−2	130	−4
1936	124	4	0	127	3	130	6
1937	129	4	0	127	−2	130	1
1938	131	6	0	129	−2	130	−1
1939	124	0	0	123	−1	130	6
1940	131	6	2	131	0	130	−1
1941	134	8	0	131	−3	130	−4
1942	132	11	0	134	2	130	−2
1943	133	8	2	133	0	130	−3
1944	130	8	0	131	1	130	0
1945	129	5	0	128	−1	130	1
1946	127	2	0	125	−2	130	3
1947	133	8	1	132	−1	130	−3
1948	124	4	0	127	3	130	6
1949	125	2	0	125	0	130	5
1950	129	8	0	131	2	130	1
1951	126	4	0	127	1	130	4
1952	123	3	0	126	3	130	7
1953	127	9	0	132	5	130	3
1954	131	5	2	130	−1	130	−1
1955	127	4	0	127	0	130	3
1956	128	4	1	128	0	130	2
1957	135	14	0	137	2	130	−5

[1] Data missing.

X_o: Observed number of days from full bloom to first 25-car day.

X_1: Number of days discounted for low maximum temperature. Scored 1 day if maximum below 54 degrees; ⅔ of a day if 54 to 60; ⅓ of a day if 61 to 65. Surplus fractions omitted; i. e., 2⅔ equals 2.

X_2: Earliness adjustment; ¼ of a day added for each day full bloom occurred before April 16 average. Surplus fractions omitted; i. e., 2¾ equals 2.

X_{oc}: Historical average number of days from full bloom to first 25-car day.

Table 1 compares our method with the industry method of calculating the number of days from full bloom to the first carlot equivalent. The standard error of estimate (table 3) is 1.67 days using our method and 3.38 days using the industry method. Our method placed all 26 years within plus or minus 3 while the industry method fell within this range in only 17 years and exceeded 3 days in 9 years. Moreover, in 15 years our method was accurate within plus or minus 1 day compared with only 9 by the industry method.

Table 2 compares our method with the industry method of calculating the number of days from full bloom to the first 25-car day. The standard error of estimate (table 3) is 2 days using our method and 3.69 days using the industry method. Our method placed 25 of 26 years within plus or minus 3, with 21 of these within plus or minus 2. The industry method placed only 16 and 11 years, respectively, within these ranges. Only one error greater than 3 was realized using our method, whereas 10 of the industry forecasts exceeds 3.

It should be noted that in 1953, the year of greatest error in our method, the first 25-car day occurred extraordinarily early—on the day following the first carlot equivalent instead of the more usual 3 to 5 days later. This phenomenon lacks clear explanation but it has been established that unfavorable weather, which included rain, immediately preceded the first carlot equivalent shipment. Possibly this contributed to unusual distortion of the normal harvesting pattern.

Whether to use the first carlot equivalent or the first 25-car day depends primarily on the eventual use of the information. No doubt the first 25-car day better expresses volume shipping, but of greater consequence may be the ability of our first carlot calculation to fall more precisely within narrow limits.

Conclusions

Results suggest that the annual differences in elapsed time from full bloom to harvest are functions of low maximum temperatures experienced during the first 10 weeks of this period. Shipment forecasts are possible because maximum temperatures below the threshold value for peaches are unlikely to be experienced after June 30.

Our methods are significantly more accurate than the prevailing industry methods relative to both the first carlot equivalent and the first 25-car day. It is believed that their use could effect savings in time, dollars, and peace of mind, especially in years of unusually long or short periods from bloom to maturity.

Our methods were tested during the 1958 season with favorable results. Full bloom occurred on April 17 followed by 3 noncreditable days. Hence, 3 days added to the 119-day base for the first carlot equivalent and the 123-day base for the first 25-car day produced forecasts of August 17 and August 21, respectively. The first carlot equivalent was shipped on August 16, and August 20 was the first 25-car day. Both forecasts were only a day off the observed. What is more important, as early as mid-June the industry was warned of an impending early harvest and thus was prepared for it.

TABLE 3.—*Variance and standard error of estimate*

Method	First carlot equivalent F_1	First 25-car day F_{25}
Authors:		
Variance	2. 80	4. 00
Standard error of estimate	1. 67	2. 00
Industry:		
Variance	11. 44	13. 60
Standard error of estimate	3. 38	3. 69

F_1: 4.086. Significant.
F_{25}: 3.40. Significant.
Ratio of the variances according to the F table indicates a significant difference between the authors' method and the industry method of forecasting initial peach shipments from Mesa County, Colo. There is no significant difference in the ability to forecast the first carlot equivalent and the first 25-car day.