Factors affecting California sugarbeet yields

Henry N. Wallace □ Hoy F. Carman

Average California sugarbeet yields have increased significantly during the last three decades. Annual variations have occurred with a slight increase between 1951 and 1968 and then a clear upward trend beginning in 1969 from about 20.5 tons per acre to 25.7 in 1980. Major factors thought to be associated with increased yields include improved pest and disease control, varieties, cultural practices, and grower knowledge. Year-to-year variations in yield may be related to weather, pest or disease infestations, government programs, and economic conditions. Average yields and rates of increase may vary by production area within California because of differences in these factors.

Our purposes here are to (1) suggest factors that may be related to average sugarbeet yields and (2) quantitatively estimate the contribution of these factors to yield increases by area within California. We developed a mathematical model to express the effects of these factors on yields, covering the 1951-1976 period for nine California production areas (table 1).

Results

The impact on yields varied by district. The variables included in each of the final equations accounted for 54 to 86 percent of the variation in annual yields during the study period (see multiple correlation coefficient values, table 2).

Temperature. Sugarbeets, especially seedlings, are vulnerable to high summer temperatures, which can weaken the plants and increase susceptibility to yield-reducing diseases. However, in the normally cool coastal districts, above-average temperatures may be associated with increased yields.

There was an inverse relationship between summer temperatures and average beet yields in four districts and a positive relationship in one. A one-degree increase in mean daily June (districts VI and X) or July (districts II and V) temperature was associated with a decrease in average yields ranging from 0.32 to 0.47 ton per acre. Average yields increased 0.79 ton per acre with each one-degree increase in mean daily July temperature in district VII, the northern coastal district.

Rainfall. Spring rainfall can delay planting, shortening the growing season, and may also prolong the flight activity of the green peach aphid. The aphid carries yield-decreasing viruses from overwintered beets to new seedlings.

Excessive total rainfall during the usual planting month was associated with reduced average sugarbeet yields in districts III, V, and VIII. Although excessive rainfall probably delays planting in other districts, we found no statistical relationship between rainfall and yields.

Acreage allotments. Government imposition of acreage allotments to control total production has often led to increased application of other inputs and use of better quality land on which to grow beets, resulting in increased average yields. Sugarbeet acreage allotments were effective during 1955-60 and 1965-66. Allotments imposed on the 1970 crop were rescinded but had an impact, because crop planting decisions had already been made.

Our model indicated statistically significant effects on average yields of 1.9 tons per acre in districts II and III and almost 2.6 tons per acre in district X. Allotments had no statistically significant relationship with average yields in other districts. Perhaps the opportunity or incentive for input substitution was absent in the other districts because of crop alternatives, rotations, and land availability.

Beet seeds. Major improvements in sugar beet seeds include development of hybrid varieties, monogerm seed, and monogerm hybrid seed resistant to curly top, leaf spot, downy mildew, yellows, and bolting. Hybrid seed resistant to curly top and leaf spot was generally available by 1959. Important varieties were USH2, USH3, USH4, USH5A, and USH5B.

Monogerm seed, which reduced the amount of hand-thinning required after emergence and thereby reduced production costs, was introduced for field testing in 1955. Pelleted monogerm seed was available to some grow-

TABLE 1. Production district designations and average sugarbeet yields, California, 1952-53 and 1979-80

District*	Counties included	Average yield 1952-53	1979-80
		Tons/harvested acre	
II	Alameda, Contra Costa, San Joaquin, Stanislaus	16.1	25.5
III	Sacramento, Solano	18.3	24.7
IV	Sutter, Yolo, Yuba	17.7	22.3
V	Butte, Colusa, Glenn, Tehama	15.5	22.7
VI	Fresno, Madera, Merced, Kings, Tulare	20.5	27.5
VII	Monterey, San Benito, Santa Clara, Santa Cruz	20.5	30.4
VIII	San Luis Obispo, Santa Barbara, Ventura	15.6	22.3
IX	Imperial, Riverside, San Bernardino	19.6	25.9
X	Kern, Los Angeles	21.6	28.5
	California Average	18.3	25.4

*Sugarbeet production in district I was phased out at the end of the 1960s when Holly Sugar's Alvarado processing plant was closed.

Analysis of yields

Changes in average annual yields of California sugarbeets by production district were analyzed using a multiple linear regression model. The model specified average annual yield per acre as a function of summer temperature, spring rainfall, the use of hybrid and disease-resistant seeds, acreage allotments, expected price of sugarbeets, and time.

Shift variables, which assumed a value of zero or one, were used to account for government acreage allotments and the use of new seed varieties.

Two zero-one shift variables were used to account for the impact of improved seeds. The coefficients for one or both of these variables were statistically significant in five of the nine districts. Trend variables to account for the impact of improved seeds, cultural factors, and other new technology were utilized in the other four districts.

A time variable was used to measure changes in yield through time in four districts that did not show a definite shift in yields with the introduction of new varieties. The time variable may capture the impact of new varieties adopted over several years as well as new production methods and grower knowledge. Variables that did not add to explanatory power were deleted from the final estimated equations.

TABLE 2. Estimated sugarbeet yield equations by Calfornia district, 1951-1976

District	Variables*									
	Constant	Summer temperature	Spring rainfall	Gov. acreage allotments	New seeds (1959-1968 = 1)	New seeds (1969-1976 = 1)	Trend	Lagged sugarbeet prices	Other†	Multi. corr. coefficient‡
	Estimated coefficients									
II	58.78	−0.32	...	1.89	2.86	9.31	...	...	...	0.81
	(2.12)§	(−1.20)		(2.14)	(3.34)	(9.87)				
III	24.90	...	−0.15	1.91	...	6.22	...	...	...	.57
	(19.65)		(−0.61)	(1.71)		(5.83)				
IV	29.64	...	...	...	...	4.02	...	...	...	.59
	(54.56)					(6.02)				
V	73.48	−0.36	−0.83	...	1.12	5.25	...	...	...	.72
	(3.96)	(−2.36)	(−2.67)		(1.82)	(7.55)				
VI	56.59	−0.41	...	...	...	...	1.34‖	0.21	...	.86
	(4.86)	(−3.45)					(7.44)	(1.70)		
VII	−46.00	0.79	...	...	...	...	1.06**	...	−5.14	.81
	(−1.84)	(2.75)					(9.16)		(−2.82)	
VIII	−67.73	...	−0.44	...	...	...	25.40††	...	...	.65
	(−4.62)		(−1.99)				(6.02)			
IX	20.70	...	...	...	...	4.16	...	...	−3.30	.86
	(79.94)					(9.50)			(−5.36)	
X	20.83	−0.47	...	2.57	...	...	0.40‡‡	0.25	−2.04	.54
	(2.27)	(−2.75)		(2.64)			(4.60)	(2.05)	(1.15)	

*The dependent variable is tons per acre.
†This is a zero-one variable, which assumed a value of one for:
District VII — 1965 and 1973, when previous-year sugarbeets were unintentionally overwintered.
District IX — 1963, 1965, and 1968, when yields were atypically low due to adverse weather.
District X — 1970 and 1971, when yields were adversely affected by erwinia root rot.
‡The multiple correlation coefficient is adjusted for degrees of freedom.
§Figures in parentheses are t-statistics.
‖The trend variable assumes the following values: 1951-1968 = 1, 1969 = 2, 1970 = 3, . . . , 1976 = 9.
**The trend variable assumes the following values: 1951 = 1, 1952 = 2, . . . , 1958 = 8, 1959-1968 = 8, 1969 = 9, 1970 = 10, . . . , 1976 = 16.
††The trend variable is the natural log of the last two digits of the year, i.e., 1951 = ln 51, 1952 = ln 52, . . . , 1976 = ln 76.
‡‡The trend variable is the last two digits of the year, i.e., 1951 = 51, 1952 = 52, . . . , 1976 = 76.

ers in 1960. Monogerm hybrid seed (USH7) was generally available by 1964, and yellows-resistant monogerm, hybrid seeds (USH9A and USH9B) were generally available by 1969.

The use of improved seed and associated technology had a statistically significant positive effect in five of the nine districts.

A cultural practice that certainly had a positive impact on average yields was the establishment of beet-free periods. During these 30-day periods (between the finish of harvest of one crop and the planting of the next) there are no sugarbeets to act as hosts for yellows viruses. Beet-free periods were formally established between 1964 and 1972, but the practice was informally followed before 1964 in some districts. Lack of information about its implementation before formal establishment precluded using beet-free period information directly in the statistical analysis.

Estimated increases in average sugarbeet yields resulting from use of improved seeds and other technology range from 4 to 12 tons per acre, or 20 to 58 percent (table 3).

Prices. Economic theory indicates that the quantity of inputs used (and yield per acre) is a positive function of expected prices and profits. Decreases in input prices or increases in expected beet prices may lead to increased use of inputs and higher yields.

Yields in the two districts that make up most of the San Joaquin Valley (VI and X) were the only ones significantly related to expected price. Yields increased 0.21 to 0.25 ton per acre in response to a one-dollar-per-ton increase in expected price, as measured by average grower price per ton lagged one year.

TABLE 3. Estimated increase in average California sugarbeet yields, 1960-1976

District	Increase due to technology, including:			Increase
	Hybrid varieties	Disease-resistant hybrid varieties	All new varieties	
	tons per acre			%
II	3	9	...	58
III	...	6	...	32
IV	...	4	...	23
V	1	5		37
VI	...	...	11	71
VII	...	...	8	32
VIII	...	...	6	28
IX	...	4	...	20
X	...	...	7	34

The absence of a significant price impact in other districts may indicate that growers make a single decision with regard to growing sugarbeets, apply a bundle of inputs based on experience, and make no attempt to change the bundle as expected prices change.

Summary

Results of this study indicate that most of the increase in average California sugarbeet yields can be attributed to new improved seed varieties generally available since 1969. Cultural practices and other technological improvements adopted with the new seeds have undoubtedly also had an impact on average yields. Weather, government acreage allotments, and economic conditions influence average annual yields, with the impact varying by production district.

The ability of the estimated equations to explain yield changes varied by district. There are several possible reasons for this variation. Individual districts, although more homogenous than the total state, may have substantial differences in factors affecting yields. There may also be problems with the selection and measurement of variables. Thus, this study is an initial effort to develop quantitative estimates of the impact of various factors in sugarbeet yields.

Henry N. Wallace is Economist, CH2M-HILL, Sacramento, California, and Hoy F. Carman is Professor, Department of Agricultural Economics, University of California, Davis.