

Comparison of four crops for alcohol yield

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One crop has no great advantage over others tested in this study

Comparison of four high-energy crops for their response to fertilizer nitrogen, yield of fermentable carbohydrates, and on-farm production costs was continued for a second year at the University of California, Davis. The 1980 trial was summarized in *California Agriculture* (November-December 1981), and we are reporting here on the second experiment, conducted in 1981.

We used the same corn (NC+ 59) and

sugarbeet (US H11) cultivars as in the first experiment but selected different cultivars of sweet sorghum (Wray) and fodderbeet (Sharpe's BMCJ/53) because of their slightly superior performance in variety trials at Davis.

Seeds were planted and irrigated for emergence on April 30. Crop plots, randomly replicated in each of three blocks, were 12 rows wide by 400 feet long and were split into six four-row



Three of the four crops evaluated for potential fuel alcohol production: corn (left), sugarbeet, and sweet sorghum.

subplots to receive fertilizer nitrogen (N) rates in 50-pound increments from 0 to 250 pounds N per acre. Starting on May 28, all crops were irrigated at two-week intervals. The estimated inches of water applied to each crop (table 1) are based on the irrigations required for seed germination — one for corn and sweet sorghum and two for fodderbeet and sugarbeet — crop evapotranspiration, an irrigation efficiency of 70 percent, and rainfall during the cropping season. The final irrigation for corn was

August 20, and the crop was harvested on September 22. The terminal irrigation for the other three crops was September 17, because two inches of rain in October eliminated the need for an additional irrigation; harvest was on November 3-4.

We obtained yields from two 25-foot-long interior rows in each fertilizer subplot. Fermentable carbohydrates (starch, sucrose, glucose, and fructose) were determined by gas chromatography of samples of appropriate plant

parts. To estimate potential alcohol production, we calculated the yields of the fermentable carbohydrates as total reducing sugars (glucose and/or fructose). Alcohol production was calculated on the basis of 14 pounds of fermentables per gallon of alcohol.

Potential alcohol yields

There were striking differences in the amounts of fertilizer N required for maximum alcohol yield, as in 1980. Corn required 200, fodderbeet 100, and sugarbeet 50 pounds per acre, and sweet sorghum none. We took these fertilization rates into account in calculating costs.

Yields of sugarbeet and fodderbeet roots and corn grain were smaller in 1981 than in 1980, but yield of sweet sorghum stalks was larger. Expressing the change in crop yields from 1980 to 1981 as a percentage of 1980 production, corn production was down 14 percent, sugarbeet down 23 percent, fodderbeet down 20 percent, and sweet sorghum up 25 percent. A portion of the increased stalk yield from sweet sorghum may be explained by considerably less plant lodging in 1981 than in 1980 and by warmer temperatures in May and June, which may be relatively more favorable to this crop than to the others. Despite the increase in yield of sweet sorghum stalks, the potential alcohol yield was depressed 9 percent when compared with 1980 estimates because of a lower concentration of sugars in the stalks.

The yield of fermentable carbohydrates, and therefore potential alcohol yield, was highest for fodderbeet, followed by sugarbeet, sweet sorghum, and corn — the same relative order of yields as in 1980.

Production costs

We estimated costs of producing fermentable carbohydrates using experimental data on yields, fertilizer, and irrigation water (table 2). Other costs were derived from standard University of California 1981 crop cost budgets for Yolo County. A cash rent charge of \$150 per acre was assumed for all crops. The costs of growing sweet sorghum and fodderbeet were adapted from the budgets for corn and sugarbeet. Both fodderbeet and sugarbeet preharvest costs were higher than for corn and sweet sorghum; in particular, the root crops had higher costs for hand labor (hoeing) and chemical use.

Harvest and haul costs for sweet sorghum were adapted from sugarcane custom rates and those for fodderbeet were taken as for sugarbeet. Total harvest and haul costs were highest for sweet sorghum. A custom rate of \$3.50 per ton was used, similar to cane and

TABLE 1. Fertilizer rates for maximum yield of fermentable carbohydrates, water inputs, crop yields, and potential ethanol production

Comparison	Corn	Sweet sorghum	Fodderbeet	Sugarbeet
Fertilizer N (lb/acre)	200	0	100	50
Irrigation: Number	8	10	11	11
Water applied (inches)	34	42	45	45
Crop production: Product	grain	stalks	roots	roots
Yield* (tons/acre)	6.64	57.7	50.7	31.3
Fermentable carbohydrates†(%)	49.8	7.0	11.2	15.9
Pounds/acre	6,613	8,078	11,357	9,953
Alcohol potential‡ (gal/acre)	472	577	811	711

* Corn grain at 15.5 percent moisture, others are fresh weight.

† Based on converting starch to glucose and sucrose to glucose and fructose.

‡ Calculated as 14 pounds of fermentables per gallon of alcohol.

TABLE 2. Cost of producing fermentable materials, based on Yolo County budgets and experimental yields

Growing costs	Corn	Sweet sorghum	Fodderbeet	Sugarbeet
Preharvest	----- \$/acre -----			
Nitrogen fertilizer				
Starter	27.75	27.75	19.00	19.00
Layby	46.00	0.00	23.00	11.50
Irrigation water	39.19	48.41	51.86	51.86
Labor	33.71	41.65	44.62	44.62
Chemicals and custom application	16.03	16.03	82.09	82.09
Thinning (electronic) and hoeing	0.00	0.00	81.71	81.71
Interest on operating capital	23.67	23.67	36.98	36.98
Land preparation and planting	61.80	51.44	74.03	74.03
Other preharvest	18.42	18.42	15.31	15.31
Total preharvest	266.57	227.37	428.60	417.10
Harvest	23.34	201.95	101.40	62.60
Hauling @ \$1.50/ton	9.96	86.55	76.05	46.95
Overhead				
Cash rent	150.00	150.00	150.00	150.00
Insurance, office, pickup truck	25.16	25.16	36.56	36.56
Bldgs. & equipment: interest & depreciation	77.57	47.88	69.84	69.84
Total	552.60	738.91	862.45	783.05
Total growing cost/gallon alcohol	1.17	1.28	1.06	1.10

TABLE 3. Potential alcohol yields and costs per gallon based on experimental yields of table 1 and their adjustment to a Yolo County average yield of 5,700 pounds sucrose per acre from sugarbeet

Comparison	Corn	Sweet sorghum	Fodderbeet	Sugarbeet
Potential alcohol yield	----- gallons/acre -----			
Experimental	472	577	811	711
Adjusted to county average beet yield	356	435	611	536
Growing costs + \$50.00/acre for:	----- \$/gallon -----			
Experimental yields	1.28	1.37	1.13	1.17
Adjusted yields	1.64	1.65	1.42	1.51



Stalk lodging is a problem in growing sweet sorghum in California. Lodging was more severe and earlier in 1980 (August 1, left) than in 1981 (August 26, right).



The fodderbeet (at left) is larger than the sugarbeet, but it has a lower sugar concentration.

sorghum rates in the South. Fodderbeet and sugarbeet harvest costs were about half those of sweet sorghum, while the cost of harvesting corn grain was much lower.

Total production costs budgeted for the four crops indicated that fodderbeet and sugarbeet were highest at \$862 and \$783 per acre, respectively. Sweet sorghum costs were slightly lower at \$739, while corn costs were considerably lower at \$553 per acre. The total growing costs per gallon of alcohol given in table 2 represent break-even costs and are lowest for fodderbeet and sugarbeet. Thus, a fodderbeet grower must receive a return of at least \$1.06 per gallon after harvesting and hauling to cover production costs.

Adjusted costs

The crop yields in this experiment are well above county averages. A more realistic appraisal of costs and returns to growers can be obtained by maintaining the relative yields of the crops in our trial but adjusting them to the average yield of sugarbeets grown extensively in Yolo County. A long-term average yield for sugarbeet in Yolo County is 25 tons of roots per acre containing 15 percent sucrose, or 7,500 pounds of sucrose per

acre that could be used to produce 536 gallons of alcohol. In our trial, corn, sweet sorghum, and fodderbeet alcohol yields were 66, 81, and 114 percent, respectively, of the sugarbeet alcohol yield. Taking these percentages, we estimated the gallons of alcohol that might be produced per acre based on the average county sugarbeet crop. These figures are given in table 3 along with alcohol cost comparisons based on the experimental and adjusted yields. In this table, we have added \$50 per acre to the break-even growing costs to provide a reasonable return to the farm operator. These costs per gallon of alcohol for the adjusted yields represent the prices a grower should receive to make it minimally profitable to grow these crops for alcohol production.

There are, of course, additional costs in producing alcohol — in the preparation of the feedstocks for fermentation, in the fermentation process itself, and in the distillation of the alcohol. Some of these costs can be offset from the sale of crop by-products — the livestock feed from the corn grain and root pulp residues — and from the use of sweet sorghum stalk residues to provide fuel for combustion.

The costs and returns considered in

this study reflect only those paid and received at the farm for alcohol feedstock. Alternative prices for the grower to consider are those for the food or feed market as compared with prices for alcohol production. At present, only corn and sugarbeet have an extensive food/feed market value and are commonly grown for these purposes. The differences in on-farm costs per gallon of alcohol are not large for the four feedstocks and, therefore, one crop has no great advantage over another. Thus it appears that growing established crops like corn and sugarbeet with food/feed alternative markets would be preferable if intensively farmed crops are to be used for alcohol production. The ultimate choice of feedstock for alcohol production may depend primarily on the costs of fermentation and distillation and on returns from by-products.

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