1973). Several researchers have demonstrated that bracken fern contains a carcinogenic substance which produces malignancies in a diverse number of animal species (I. A. Evans, B. Widdop, R. S. Jones, G. D. Barber, H. Leach, D. L. Jones, and R. Mainwaring-Burton, "The possible human hazard of the naturally occuring bracken carcinogen," *Biochem. J.*, 1971; and C. Y. Wang, A. M. Pamukcu, and G. T. Bryan, "Detection of carcinogenic activity in different extracts of bracken fern," *Proc. Ann. Assoc. Cancer Res.*, 1973). Transfer through milk has been established by I. A. Evans, R. S. Jones, and R. Mainwaring-Burton ("Passage of bracken fern toxicity into milk," *Nature*, 1972), but whether the carcinogen is transmitted through meat is not clear.

These studies are especially significant for people who consume bracken fern directly as well as for livestock and dairy producers. Numerous methods of bracken-fern control have been tested: controlled fire, mechanical removal, tillage, and herbicides are some examples. However, little success has been achieved with any method.

Experimental procedure

Four separate experiments were established from May 23, 1974 through August 28, 1975 in Mendocino County to compare the effectiveness of three herbicides for bracken fern control. Herbicides studies were dicamba (Banvel), glyphosate (Roundup), and asulam (Asulox). All herbicide treatments were made to fully expanded fronds in either 200 ft^2 or 400 ft^2 plots. Bracken fern density (stand) and fresh weight reduction were determined after 10 to 25 months from application.

Herbicide effects

Of the three herbicides tested, dicamba provided the least bracken fern control. At the lowest application rate (1 lb/A) neither stand nor fresh weights were reduced by more than 31 percent of the non-herbicide treated control (fig. 1). A higher rate (2 lb/A) of dicamba did not appreciably increase the amount of bracken fern controlled.

Bracken fern was effectively controlled by either glyphosate or asulam. Applications of glyphosate resulted in 96 to 100 percent stand reduction and 98 to 100 percent decreased fresh weights (fig. 1). Significant reductions in bracken fern stand (88 to 92 percent) and fresh weights (83 to 93 percent) also occurred with asulam (fig. 1). In contrast to glyphosate, where necrosis of exposed fronds occurred rapidly after application, asulam-treated plants did not die for several months after application. However, the following spring new fronds did not emerge from the asulam-treated areas. No bracken fern regrowth was observed in plots treated with either herbicide after 25 months.

In these study sites grasses and forbs were generally missing. This is due to the extensive canopy and competitive effects of bracken fern on other plants. Phytotoxicity to treated grasses and forbs from glyphosate was minimized by making applications in late May when most annual grasses and forbs had matured. It is apparent from these studies that either glyphosate or asulam provide an effective means for the control of bracken fern. Asulam is registered for bracken fern control in forestry; however, asulam, dicamba, and glyphosate are not currently registered for use in rangeland.

Steven R. Radosevich is Assistant Professor, Department of Botany, Davis; William H. Brooks is Farm Advisor, Ukiah; David R. Adams is Research Assistant, Plant Growth Laboratory, Davis; Walter B. McHenry is Extension Weed Scientist, Department of Botany, Davis.

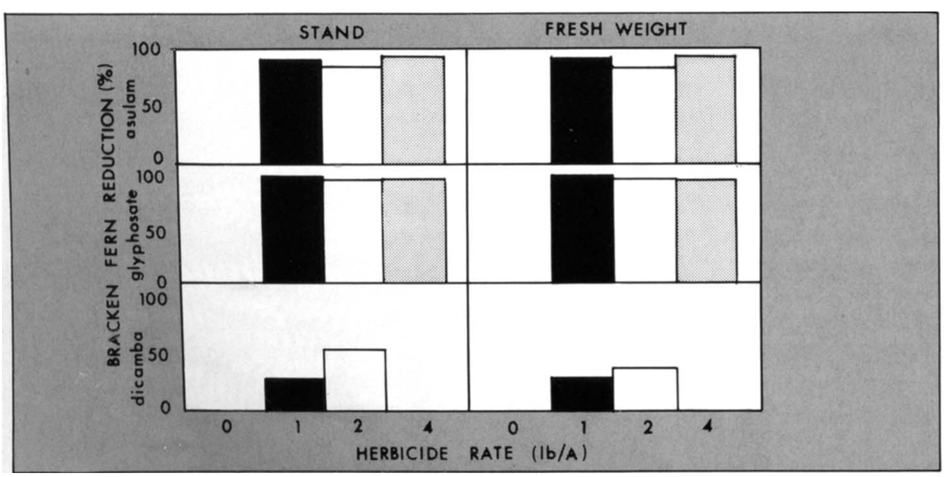

Fig. 1. Bracken fern control with three herbicides.

Sugarbeet: an efficient user of soil nitrogen

F. Jack Hills

Gary R. Peterson

New measuring techniques have enabled researchers to accurately estimate the amount of N to apply to achieve maximum sugar yield.

Using a new technique to measure precisely the uptake of fertilizer nitrogen by plants, experiments at UC Davis have shed new light on the use of soil and fertilizer nitrogen by sugarbeets. Natural nitrogen (N), as it occurs in the atmosphere, soils, plants, and fertilizer, contains a small but readily measurable amount of nitrogen-15—about 0.366 percent. Crops feeding on soil N or ordinary fertilizer N will contain nitrogen that has about the same percent of N-15. If a crop is fertilized with nearly pure N-14, the percent of N-15 in its tissues will be reduced in direct proportion to the amount of fertilizer N-14 taken up. Thus, by determining the ratio of N-15 to N-14 in unfertilized and fertilized plants, the experimenter can tell how much of the N in the crop came from the fertilizer.

Time of application

In a 1975 experiment, sugarbeets were fertilized with 120 pounds of N-14 ammonium sulfate applied in four different time patterns: all at planting, all at thinning, split equally between thinning and layby, and divided equally among planting, thinning, and layby. (Layby is the stage of crop growth just before leaves close the furrows between the plant rows.) Control plots were not fertilized. Sugarbeets with and without fertilizer N yielded 39.4 and 28.9 tons of roots per acre, respectively. There were no significant differences in either root or top yields associated with time of fertilizer application. All fertilized plants contained about the same amounts of soil and fertilizer N at harvest, indicating that sugarbeets can be fertilized at any time from planting to mid-season without seriously affecting the efficiency of N uptake from fertilizer.

Effect of rate of fertilizer N

In the second experiment, conducted in 1976, sugarbeets were fertilized with N-14 ammonium sulfate in amounts varying from 0 to 250 pounds N/acre, in 50-pound increments. Maximum sugar was produced with 100 pounds of fertilizer N/acre (fig. 1). The increased yield from the last 25 pounds of N applied to reach the 100-pound level did not quite pay for the additional cost, so if the response curve had been known prior to fertilizing the choice of 75 pounds of fertilizer N would have maximized net return.

Knowing how a given field will respond to fertilizer N is a major problem. Fields vary in response, with some not responding at all and others requiring more than 200 pounds/acre. Techniques of soil and plant analysis have been developed to aid growers to more accurately estimate the amount to apply to just achieve maximum sugar yield.

In fig. 1, note how total crop yield (tops + roots) increased with fertilizer application far beyond that needed for maximum root and sugar production. The lure of maintaining large green tops until late in the growing season can trap a grower into overfertilization and consequently lower his net return.

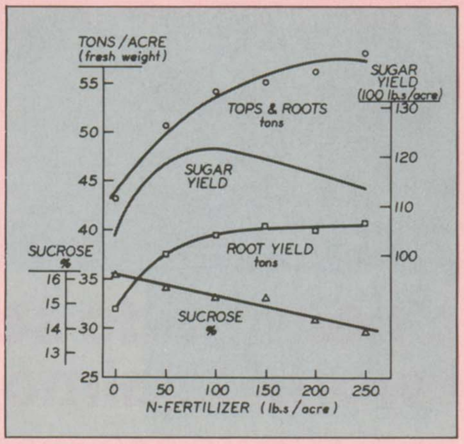

Fig. 1. Response of sugarbeets to fertilizer N at Davis in 1976. Note that maximum sugar yield occurred at a lower fertilizer rate than total crop yield.

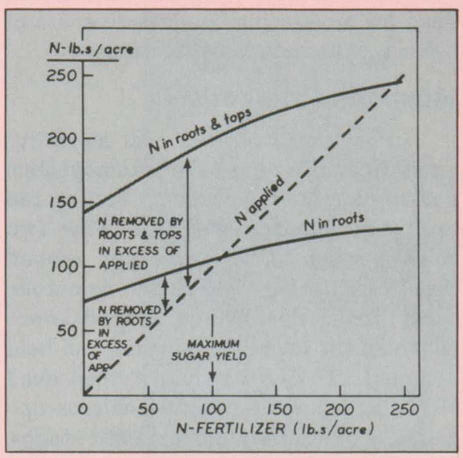

Fig. 2. Effect of fertilizer N on total N in the crop and on N subject to long-term leaching.

Effect of Rate of Fertilization on Fertilizer and Soil N in Sugarbeet Crop (Tops + Roots)

Fertilizer N applied	Crop N from: soil	fertilizer	
	lb/acre		%
0	141	0	—
50	152	21	12
100	152	47	24
150	152	68	31
200	149	86	37
250	146	99	40

The table shows fertilizer and soil nitrogen in the crop at the different treatment levels. Apart from a slight increase with the first increment of fertilizer N, the amount of soil N taken up was constant at about 150 pounds/acre. Fertilizer N, on the other hand, increased in the crop with fertilizer applied. The crop that produced maximum sugar obtained 76 percent of its N from the soil and only 24 percent from the fertilizer. In contrast, an experiment conducted by Dr. F. E. Broadbent at Davis in the same year on a similar soil showed that field corn, when fertilized for maximum grain yield, obtained 44 percent of its N from the soil and 56 percent from the fertilizer. Thus, it appears that sugarbeet roots may more thoroughly penetrate the soil and therefore use soil N more effectively than corn. The development of information on the comparative abilities of different crops to utilize soil and fertilizer N should help establish rotation systems to improve the efficiency of fertilizer use.

Potential nitrate pollution

An effective way to minimize agriculture's contribution to nitrate in groundwater is to maximize the N removed by a crop: nitrogen applied in excess of that removed is potentially leachable. With sugarbeets, N fertilization for maximum sugar yield results in the production of a large quantity of root dry matter that usually contains as much or more N than was added as fertilizer (fig. 2). Thus, fertilizing for maximum sugar yield would not be expected to contribute to nitrate pollution. In addition, sugarbeet tops left in the field contain N (in this trial 98 pounds/acre) that is protected from much leaching until the tops decompose. Nitrogen released at this later time can reduce the fertilizer requirement of the following crop.

The efficient use of fertilizer N for sugarbeets requires just enough N to achieve maximum sugar yield, and no more. At the correct application rate all benefit: the farmer maximizes net income; the processor obtains good quality beets for processing; energy for the manufacture of fertilizer is not wasted; excess N is not left in the soil to leach to groundwater; and the production of needed food calories is maximized.

F. Jack Hills is Extension Agronomist and Gary R. Peterson is Extension Staff Research Associate, Department of Agronomy and Range Science, Davis.