SUGARBEET STAND ESTABLISHMENT IN THE U.K. - A U.S. PERSPECTIVE

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Economic, social, and political issues have caused changes to occur in sugarbeet plant establishment practices in the United Kingdom over the past several decades. As elsewhere, growers there are continually striving to make changes which provide greater economic return for their inputs. Short term economic incentive was important, but perhaps even more influential motives for change were social and political issues. Prior to the 1970's, most British growers planted excess seeds, then manually thinned the fields to the desired population, as was the practice in the rest of the sugarbeet growing world. Labor costs increased and labor gradually became unavailable. It was necessary to develop and utilize plant-to-stand practices. Politically, participation in the European Common Market required Great Britain to maintain production competitiveness with other leading sugarbeet producing countries in Europe. Change was necessary.

Changes in primary production practices that affected plant establishment focused on the goals of planting-to-stand (eliminating thinning), improving plant spacing accuracy, increasing seedling emergence, and increasing harvest population---all while increasing yields and net production returns. Great Britain has made substantial strides in reaching these goals through cooperative effort within the industry, focused research programs, and grower acceptance of proven practices. These same goals, and the resulting cropping practices, have application to many of the sugarbeet growing regions of the United States.

I had the opportunity to observe in detail the seedbed preparation, planting, and early plant establishment period of the English sugarbeet crop during five months in early 1991. I was on a faculty development leave from my position as an Agricultural Engineer at the University of Nebraska Panhandle Research and Extension Center in Scottsbluff, NE. My hosts in England were British Sugar, Germain's, and Stanhay Webb. My objectives were to observe grower practices and results, visit organizations with substantial research effort on sugarbeet plant establishment, and to view the current level of plant establishment technology with a perspective of the field practices currently used in Nebraska and similar United States growing areas.

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Brief Overview of British Sugarbeet Industry

The first sugarbeet processing factory was built in Great Britain in 1912. By the late 1920's the number of factories had grown to 18, with ownership by 13 separate companies. In 1936 these factories were amalgamated by an Act of Parliament to form one organization named the British Sugar Corporation. The government remained a controlling shareholder until 1981 and in 1982 the Corporation was acquired by Berisford International. Associated British Foods purchased British Sugar from Berisford International in early 1991. British Sugar purchases on contract the entire sugarbeet crop grown in Great Britain and supplies more than one half the country's sugar needs. The crop is processed in 10 factories as of 1991, with individual factory capacity ranging from 4000 to 12,500 t/d. The Company maintains an extensive Research and Development facility for crop production and a network of crop advisers to work closely with growers.

Nearly 180,000 ha of sugarbeets are grown annually in England by some 10,000 growers. The major sugarbeet growing areas are East Anglia, Yorkshire, Lincolnshire, and the West Midlands. Grower size ranges from 2 ha to 900 ha of sugarbeets. Current average clean root yield is 47 t/ha with a sugar content of 17.5 percent for the British crop.

Part of the successful advancement in sugarbeet production technology in Great Britain must be credited to the organizational structure of the entire sugarbeet industry. One important element in this structure is the Sugar Beet Research and Education Committee created by Parliament to administer an industry funded research program. This Committee is comprised of members from British Sugar, The National Farmer's Union, several governmental bodies, and independent members. Funding for the work of the Committee is a joint contribution from both sugarbeet growers and from British Sugar. The Committee commissions research on all aspects of sugarbeet crop production, including plant disease, weed control, fertility, and mechanization. Funded research totaled nearly £2,200,000 in 1991. Approximately 60 percent of this funding was directed to Broom's Barn Experimental Station, which has sugarbeet crop research as a sole purpose. Other facilities receiving significant research funding in 1991 included the National Institute of Agricultural Botany, Morley Research Center, Rothamsted Experimental Station, Harpenden Laboratory, Gleadthorpe Experimental Husbandry Farm, Silsoe Research Institute, Arthur Rickwood Experimental Husbandry Farm, and British Sugar Research and Development Center. Funding for the educational effort is provided to British Sugar for field demonstrations and written publications such as the British Sugar Beet Review.

General Agronomic Conditions in British Sugarbeet Fields

As in the United States, conditions vary from field to field and year to year in British sugarbeet fields. Soil types vary greatly, and include peaty loams, silts, clay loams, and coarse sandy loams. Some growers must deal with several soil types on the same farm, necessitating differences in tillage and other cultural practices. Crop rotations vary by area, but sugarbeets are not grown more than once in a three year period. The crop rotation often

includes wheat, barley, potatoes, and oil seed rape. Average annual precipitation is 60 cm, with substantial variation between years and among months of the year. Approximately ten percent of the sugarbeet crop has provision for irrigation.

The sugarbeet growing season is limited in the spring by steady cool soil temperatures which can cause plant bolting, and in the fall by the necessity of harvesting before inclement weather. Planting season typically falls in the period from mid-March to Mid-April and is influenced by soil temperature and moisture. The months of March, April, and May are generally cool with slow plant development. Harvest begins in early October and is normally completed in December. Sugarbeets are delivered direct to the processing factory from the field or are stored in piles on farm for later delivery. Deliveries to the factory are complete by early-February.

Plant Establishment Goals

Successful plant establishment is the first, and perhaps most important, goal of the British sugarbeet grower. Plant establishment is characterized in several ways, including plant canopy development, population, plant spacing, and seasonal growth. Jaggard and Clark (1990) described the method used in England to predict sugarbeet yield on a large area basis and the accuracy of that method. The basis for the method is that in general each megajoule of energy from the sun intercepted by the beet crop is converted into approximately one gram of sugar at harvest. Thus the sooner plant leaf area develops, and the more complete the field area is covered with sugarbeet plants, the higher the yield. This relationship implies that emergence and early growth should occur as soon as possible, plant population should be relatively high, row spacings should be narrow, and there should be minimal gaps between rows and between plants within the rows. Related cultural practices such as pest control and fertility must coincide with these plant establishment goals.

What specific practices do the British sugarbeet industry use to attain these plant establishment goals? I posed this question to a range of people in the sugarbeet industry including researchers, growers, British Sugar crop advisers, planter manufacturers, and seed processors. I observed seedbed preparation, planting, and early crop development on a large number of farms. I also measured "stand" in typical grower fields. From the perspective of this experience within the British sugarbeet industry and my reference of Nebraska practices, four critical practices were used by British growers who consistently achieved high plant establishment performance:

- Proper seedbed preparation
- High quality, enhanced, pelleted seed
- Precision planters
- High plant populations in narrow rows

Proper Seedbed Preparation

Spring seedbed preparation for sugarbeets in England has gone from intensive to minimal. Soil type, crop rotation, and wind erosion potential have a bearing on the timing,

the number, and the type of tillage operations prior to planting. Heavy clay type soils usually require fall plowing with a trailing press, over-winter weathering, and even power harrowing to break down clods. Soils with a predominate sand composition are often plowed and seeded with a cover crop several weeks before planting with no secondary tillage. For more general soils, growers plow with a trailing press in November or December. The trailing press firms the soil, breaks large clods, and leaves the surface with small ridges and clods to help control wind erosion over winter. By March the soil surface layer has weathered from the freezing-thawing cycles and, except for levelness, is often an ideal seedbed. The preference is for one or no tillage passes prior to planting. If a separate tillage operation is not used, the planter tractor can be equipped with a strip tillage implement, or the planter can be equipped with clod pushers to level the soil surface in the row area.

If a secondary tillage operation is used, there are specific preferences on the method. Tillage should occur within hours, not days or weeks, of planting to conserve soil moisture for the planting operation. Often, the tillage implement operates only several passes ahead of the sugarbeet planter. The depth of tillage should be very shallow, only 3-6 cm deep. This conserves soil moisture, and causes minimal disturbance of the unweathered soil. Deeper tillage would bring up clods, which would then have to be broken up. Deeper tillage would also bring up moist soil to dry out, and put drier soil below. Growers want drier, larger soil particles on the surface and fine, firm, moist, consolidated soil at seed depth.

The tillage implements used in British sugarbeet fields are different from those used in most fields in the United States. The implements have vertical tines, sometimes powered, that are closely spaced. The soil engaging section of the tines is vertical, not "C" shaped, so the principal action is horizontal stirring and not vertical stirring or inverting. The goal is to leave dry soil and small clods on the surface and moist, fine soil at seed depth. The implement will have a firming device, such as a roller, at the rear to provide soil firmness.

Tractor tire tracks between plowing and planting operations are minimized or controlled. Any preplant fertilizer is applied before plowing. Tractors are equipped, and matched to the tillage implement, in a manner to minimize the depth of tire tracks. The use of dual wheels, both front and rear, is common. Deep tire tracks would require deep tillage which is to be avoided. Operators use narrow implements which require minimal tractor ballasting, or many use wide flotation tires, to limit deep tire tracks. Some growers use controlled traffic schemes, with markers on the tillage implement to allow the planter tractor to use the same tire tracks as the tillage tractor. These limited or controlled traffic systems improve tillage performance, improve planter performance, and also reduce soil compaction problems in sugarbeet fields. Gummerson (1986, 1988, and 1989) described field research which provides a basis for the recent trends in sugarbeet tillage practices and the impact on stand establishment.

Pesticides and fertilizers which might adversely affect plant establishment are limited or not used in the seedbed.

High Quality, Enhanced, Pelleted Seed

The British sugarbeet industry attributes much of the improvement in plant establishment over the past twenty years to advanced seed technology. This technology includes higher germination, improved pelleting, and seed enhancement. The minimum sugarbeet seed germination standard was 73 percent in 1970 and has increased, on a voluntary basis, to 90 percent by 1990 (the statutory minimum is still 80 percent). Average germination levels of commercial seed lots have increased from 88 percent in 1979 to 96 percent in 1989 (Kimber, 1990). This increase in laboratory germination provides an even greater increase in field emergence because of the attendant increase in seedling vigor and less variation in germination (Prince and Durrant, 1990, and Durrant, Bould and Brown, 1985). These improvements have come about because of an industry commitment to higher quality seed, and include improved seed production practices in the field, better harvest methods, and attention to seed selection and handling. All seed used in England is grown in southern France and northern Italy where the climate allows production of a high quality seed.

The pelleting process was originally intended to make an irregular shaped, and nonuniform sized seed into a consistent sized, round shape to permit improved planter performance. That aspect has succeeded, and in addition over the last twenty years the pelleting material and process have provided equivalent or improved emergence of pelleted seed compared to unpelleted seed (Durrant and Loads, 1984 and Fletcher, 1984). More recently, steeping, new fungicide combinations, and insecticides have enhanced the pelleting process to improve emergence and protect the seedling from pathogens and insects (Prince and Durrant, 1990). All sugarbeet seed sold for the English crop is pelleted.

Precision Planters

Planters used for sugarbeets in England are selected on the basis of performance for emergence and spacing of sugarbeets. Occasionally growers use the same planter for crops such as onions or carrots, but usually the planters are designed, selected, and used specifically for sugarbeets. This is in contrast to many sugarbeet growers in the United States who have general purpose planters designed for corn and soybeans, but adapted for sugarbeets. Sugarbeet planters used in England have narrow shoe type furrow openers and a seed drop from the cell wheel or belt to the furrow bottom of less than 4 cm. This is another contrast to the United States where some planters have seed drop distances as much as 60 cm. The four most popular planter models used in England are the Stanhay S981 belt type, the Webb in several similar versions, the Stanhay Webb Rallye 590, and the Accord-Fahse Monocentra SP. Comparison tests are conducted periodically to provide growers with emergence and spacing performance data on available models (Thomson, 1986). These tests also convey to the grower the importance of field speed with a particular planter model. Although some of the planter models can demonstrate good seed spacing accuracy in a static laboratory test at simulated forward speeds up to 8 km/h, most British growers maintain planter field speed below 6 km/h. Slower field speeds provide better seed spacing accuracy and better depth control. Growers are encouraged to add planter row units to their planter tool bar to increase field capacity---not to increase field speed.

An organized, planter preventative maintenance program has also proven to benefit stand establishment in British sugarbeet fields. The maintenance service is provided by British Sugar and is available at each factory location during a specified time period each year prior to planting season. Each unit is examined on a sticky belt test station for an initial reference of seed spacing. The units are dismantled and inspected for adjustment, wear, or malfunctions. It is operated over the sticky belt a second time after replacing any needed parts, and making adjustments. A survey of British sugarbeet growers found that 35 percent of all sugarbeet planter units are inspected annually, 35 percent are inspected one year in three, and the remaining 30 percent have never been inspected for testing. Typically, 12,000 planter units (rows) are inspected within the program each year, and over 50 percent fail the initial test criteria and are corrected (Bastow and Goddard, 1986).

High Plant Populations in Narrow Rows

The plant population goal for British sugarbeet growers is 75,000 to 100,000 plants/ha of established plants. Jaggard (1990) discussed established plant populations from 75,000 to 100,000 plants/ha in row spacings of 41 to 51 cm were optimum for maximum sugar production. He further indicated that the correct population must be accompanied by uniform spacing of plants within that population. Large gaps between plants contribute to increased weed pressure, more Virus Yellows disease, and harvest difficulty. The annual British Sugar Crop Survey (Prince and Durrant, 1990) showed that in 1981, less than 30 percent of the national crop was grown with at least 75,000 plants/ha. When averaged over the five year period 1985-1989, 70 percent of the crop had an established plant population over 75,000 plants/ha. During this same period, the surveys indicated 19 percent of the crop was only slightly below the minimum target population, and 11 percent had rather low, gappy stands.

The traditional and most common row spacing within the British sugarbeet industry is 51 cm. As growers realize the benefits of plant canopy cover, there is a trend to more 46 cm row spacing, or to a flat bed system using four rows spaced 41 cm apart within a bed and 61 cm separating beds. The bed system accommodates wider tractor tires and controlled traffic.

As a result of a combination of improved tillage practices, planter design and operation, and seed improvements, plant stand establishment has substantially improved during the 1980's. If plant establishment is defined as the percentage of intended seed positions occupied by an established plant, then plant establishment has increased from 60 percent in 1981 to 71 percent in 1989, averaged over the British crop (Jaggard, 1990). Maximum yield is regarded as requiring a minimum of 70 percent stand establishment to minimize effects of gaps between plants.

Stand Establishment Performance of Selected British Growers in 1991

I had the opportunity to extensively observe British sugarbeet grower practices during the tillage, planting and early plant growth stage during the period March-July, 1991. Fourteen fields were selected as typical fields representing a range of soil types, planter models, seedbed preparation methods, grower scale, and grower management styles. I observed the tillage operations, planting, emergence and plant growth in each field. When the

plants reached the four-six true leaf stage, considered established plants, I measured the locations of 51 consecutive plants within a row in ten random sites within each field. From these measurements I estimated "stand" in Table 1 and described the plant spacing accuracy in Figures 1-2. This data should not be construed as an average performance of British growers but rather as a yardstick of the performance that is possible.

The stand establishment performance in these 14 fields is the combination of many factors including soil type, weather, planter, seed, seedbed preparation, etc. Several fields had excellent stand, both in percent of plants in positions where seeds were intended and in accuracy of spacing between plants. Several fields were marginal, in comparison. Fields 4 and 14 were exceptional, both in percent stand and in spacing accuracy as shown in Table 1 and Figures 1-2. Field 12 was plagued with perhaps two problems. First, it was planted with a new 18 row planter which was not spacing the seeds as well as it should have. This field received no secondary tillage between the fall plowing-pressing operation and planting as part of the wind erosion control plan. Planting directly into the weathered ridges left by the plow press probably contributed to inconsistent seed depth control and in-row spacing. Second, it was observed that a number of plants were lost to insects and birds between germination and the time of measuring.

To indicate the variability of factors involved in stand establishment, fields 2, 3, 4, and 5 used the same model of planter. Seed spacing accuracy varied in these fields, with field speed, seedbed condition, and planter maintenance as likely differences. Field 14 was planted as a bed system of four rows spaced 41 cm apart and 61 cm between rows of adjacent beds. This grower used one seed spacing for the middle two bed rows and a shorter spacing for the two side rows, thus the "fields" are labeled 14A and 14B in Figure 2.

Conclusions

The United Kingdom sugarbeet industry has made substantial advancements in sugarbeet plant establishment over the last 20 years. All fields are now planted-to-stand, and hand labor for thinning the crop or removing weeds has essentially been eliminated. Plant populations are consistently higher within the target range and there are fewer large gaps between plants. There is a higher percentage of established plants where seeds were intended. This has contributed to lower production costs while increasing sugar yields.

Improvements in established plant stands in the British sugar crop have been attributed to improved seedbed preparation; high quality, enhanced pelleted seed; precision planters; and high plant populations in narrow rows.

Acknowledgement

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Table 1. Sugarbeet row spacing, population, and estimated stand establishment in fields of 14 selected sugarbeet growers in England in 1991.

Field No.	Row Spacing (cm)	Plant Population (plants/ha)	Estimated Stand Establishment* (percent)
1	46	94,100	85
2	51	76,100	75
3	51	85,700	80
4	51	114,700	95
5	51	108,000	86
6	51	93,900	89
7	51	90,900	84
8	46	82,800	76
9	51	111,400	92
10	51	102,100	85
11	51	96,100	87
12	51	62,000	65
13	51	88,200	81
14	61-41-41-41-61	115,000	92

* The stand establishment values are the percentage of plants which were present at the four true leaf stage compared to the estimated number of intended seed stations for a given row length. The intended seed spacing was determined from the frequency diagram as the most frequent spacing in the first node. This is not necessarily a good estimate of emergence, due to possible post emergence plant mortality, nor will it provide a good estimate of stand if frequency nodes are not distinct.

Percent Stand Establishment (for a given length of row) =
100 * (no. of plants) / (no. of intended seed stations)

No. of Plants = 1 + no. plants within first node range + no. plants within second node range + no. plants within third node range + no. plants within fourth node range + no. plants within fifth node range

No. of Intended Seed Stations = 1 + (1 * no. plants within first node range) + (2 * no. plants within second node range) + (3 * no. plants within third node range) + (4 * no. plants within fourth node range) + (5 * no. plants within fifth node range)

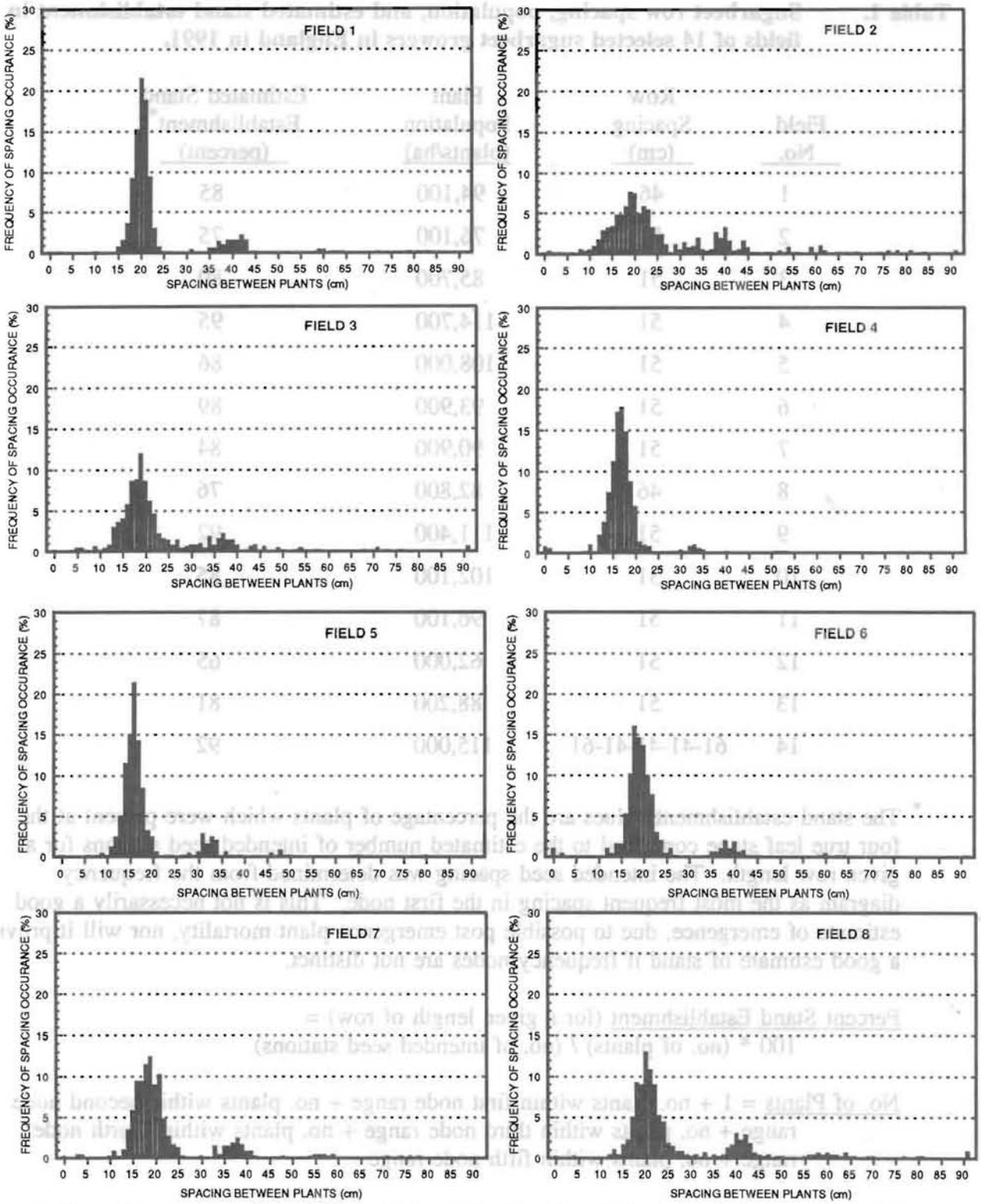

Figure 1. Plant spacing performance for selected British sugarbeet fields. Measurements include 500 plant spacings at the 4-6 true leaf stage.

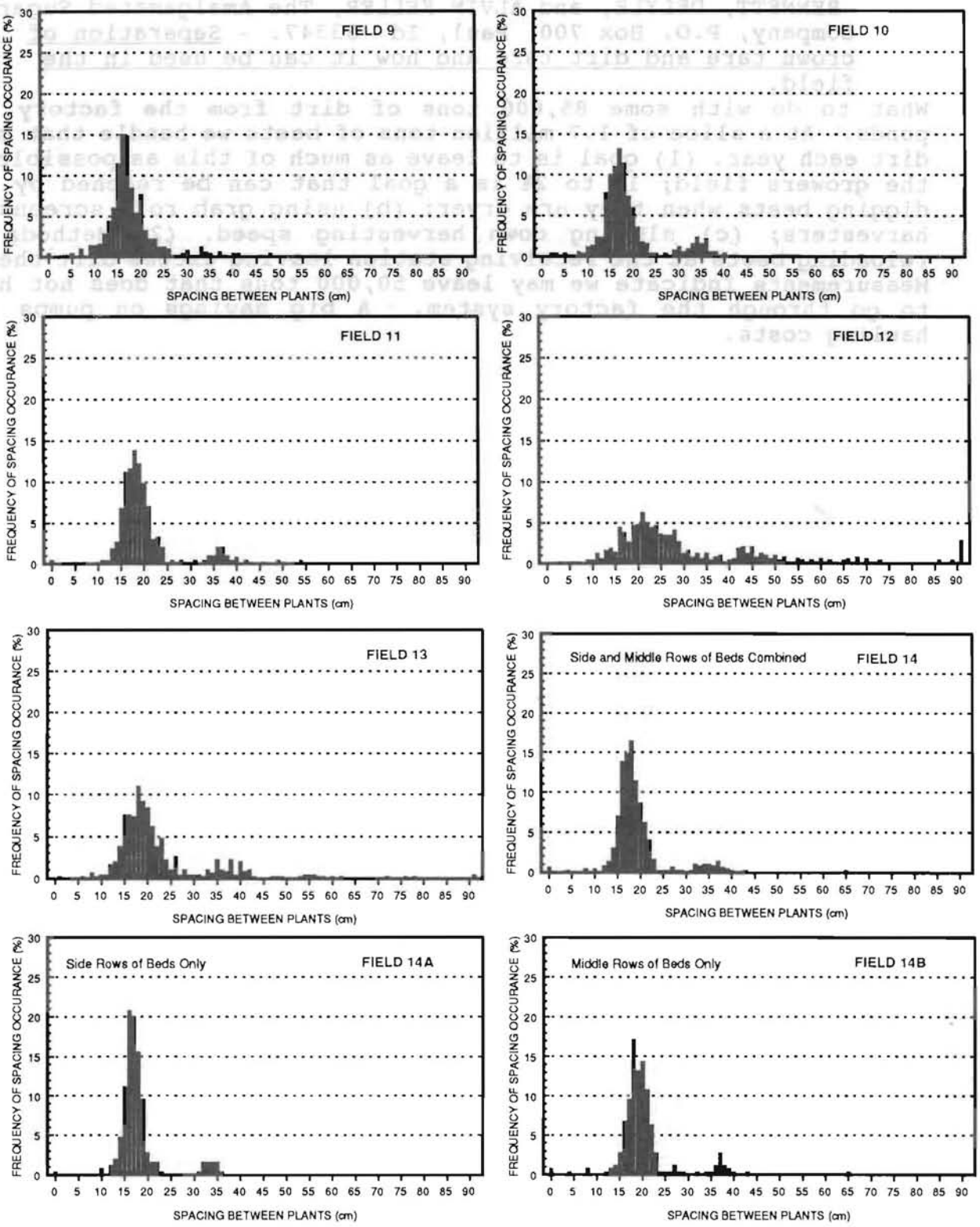

Figure 2. Plant spacing performance for selected British sugarbeet fields. Measurements include 500 plant spacings at the 4-6 true leaf stage.