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Allometric growth analysis of sugar beet
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of the requirements for
Ph.D. degree in Crop Science

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ALLOMETRIC GROWTH ANALYSIS OF SUGAR BEET

(BETA VULGARIS L.)

By

Ukun Sastraprawira

A DISSERTATION

Submitted to

Michigan State University

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ABSTRACT

ALLOMETRIC GROWTH ANALYSIS OF SUGAR BEET (BETA VULGARIS L.)

By

Ukun Sastraprawira

Allometric growth of four sugar beet lines with high, four lines with low TLWR and two commercial hybrids were studied in the field, in pots and tiles outdoors, and in the growth chamber during 1975, 1976, and 1977 at East Lansing, Michigan.

TLWR of both high and low lines increased as the plant aged with a value of 0.11-0.42 for high, and 0.12-0.20 for low lines in the seedling stage. In the later stage a value of 2.30-4.85 was obtained for high, and 1.60-4.12 for low lines. TLWR of the commercial hybrids was 0.20 in the seedling, and 1.82 in the later stage.

There were no significant differences in the final tap root yield between lines with high and low TLWR. The commercial hybrids had significantly higher final dry weight of tap root than lines with high or low TLWR.

There was a trend that lines with high TLWR to have higher percentage of dry weight of tap root in the seedling and in the later stage, and lower percentage of dry weight of leaf blades, petioles, and fibrous roots. The percentage

of dry weight of crown in the later stage was about the same between lines with high and low TLWR.

No significant differences were obtained in sugar analysis between lines with high and low TLWR and the commercial hybrids.

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INTRODUCTION

Agriculture, in many cases, will profit by a dry matter accumulation which is as large as possible in the product to be harvested. The parts which cannot be harvested in a certain sense are ballast but often a necessity, as they serve to provide the product to be harvested with essentials for its development. There is no gaining of grain without straw or sugar beetroot without foliage. The question that may be asked is, whether it is possible to increase the useful output by influencing the percentage of dry matter in the product to be harvested?

Much research has been done on the sugar beet (Beta vulgaris L.) in trying to solve problems of obtaining a high-quality, high-yielding crop. One attempt has been done by Dr. F.W. Snyder from USDA at Michigan State University to reduce the maintenance of top growth at the expense of storage root formation. Sugar beet plants of line EL 40 were selected for extreme value of the Tap root-Leaf Weight Ratio (TLWR). TLWR is devined as Tap root-hypocotyl fresh weight/Leaf blade fresh weight ratio. The first selection parents produced seeds and have been progeny tested. The slope of the regression of leaf blade weight and tap root-hypocotyl weight for the low and the high progenies

differed significantly from the original sample. A second selection has been made out of the low and high samples during progeny testing and has produced seeds.

The objectives of this study were to study the partitioning of photosynthate using allometric growth analysis on noncompetitive plants by measuring weight of the various plant parts; and to see if (1) selection of TLWR has altered partitioning or relative growth among plant parts, (2) relationships and trends in the seedling stage (20-40 days after emergence) hold for plants 100 days old, and (3) lines with high TLWR produce larger tap root.

REVIEW OF LITERATURE

The manner in which dry matter is partitioned between the different parts of the plant is clearly of great importance in crop production. Indeed, the possibilities of changing the distribution of assimilates in crops, either by chemical growth regulators or by breeding, offer some of the most promising ways of increasing agricultural productivity.

Normally, the regions of assimilate production (the leaves) are separate from the regions of consumption (the growing regions or storage organs). However, a developing leaf may both produce assimilates itself and import them from other parts of the plant. These regions of production and consumption are referred to as source and sink for assimilates, respectively. Thus assimilates move from source to sink via the transport system of the plant.

According to Evans (1975) sinks are regions of net import, usually but not always converting soluble compounds from the phloem into less soluble and more complex storage, structural and enzymatic components. Such sinks are of several different kinds, and different mechanisms for unloading may prevail in them. Meristematic sinks are characterized by active cell division, and possibly by high

endogenous production of cytokinins. Elongation sinks are characterized mainly by cell wall synthesis and rapid water uptake, and possibly by high endogenous levels of gibberellins. Storage sinks are of two kinds, one characterized by conversion of the soluble phloem components to insoluble polymers, as in the cereal grain, the other by extremely high levels of soluble sugars which may be loaded against a gradient of concentration.

There is a need of obtaining an estimate of sink strength. In most circumstances, dry matter accumulation by various plant parts provides some indication of the competitive ability of a sink to attract assimilates relative to other sink regions rather than an estimate of the potential capacity to accumulate assimilates, and also provides a valuable basis from which source-sink relations may be examined. The ratio of dry weight of different plant organs to total dry weight, describes the biomass distribution within the plants (Kvet et al., 1971). A special case of such a ratio is called the harvest index or coefficient of economic yield, i.e., the ratio of dry weight of economically important plant parts (e.g., grain in cereals, root in sugar beet) to total dry weight or sometimes, just the dry weight of above ground plant parts.

The approach to the problem of assimilate partitioning will depend upon whether one is concerned with (1) total dry matter production and utilization within the whole

plant; (2) partitioning, as between the whole shoot and the whole root, or (3) partition of assimilates within the individual parts of the shoot.

Total Assimilate Accumulation Within the Whole Plant

The total net production and net consumption (i.e. in growth and storage) of assimilates within the whole plant must be in balance. Two possible situations may be envisaged: (1) the actual rate of assimilate production is less than the potential maximum rate of consumption, or (2) the potential rate of production is greater than the actual rate of consumption. Thus, the overall rate of assimilate accumulation in (1) is determined by the rate of production (source limitation), and in (2) by the rate of consumption (sink limitation). In most cases this would appear to be valid (Milthorpe and Moorby, 1969) but several reports suggest that, at least in some circumstances, the transport system may restrict transfer of assimilates from source to sink (Geiger, Saunders and Cataldo, 1969; Jenner and Rathjen, 1972).

The sink strength of the whole plants exhibits considerable elasticity. For instance, growth and branching patterns of shoots and roots of whole plants are usually indeterminate, thus offering an array of competing sinks which may be expected to readily absorb any increases in assimilate production. Furthermore, if conversion to structural components is reduced, assimilate consumption

can be diverted into accumulation of food reserve. At first sight, therefore, it would seem unlikely that overall accumulation is limited by sink strength. However, under field conditions assimilate utilization may be limited by various external factors.

Wardlaw (1968) pointed out that the actual process of food transport is probably of minor importance in determining distribution patterns in response to environmental changes.

He considered temperature to be more directly related to growth than to either translocation per se or photosynthesis. Light affects translocation through photosynthesis, growth and development. Water stress exerts direct effects on photosynthesis and on growth; its effects upon translocation are indirect. Luckwell (1960) found three major environmental factors influencing the root/shoot ratio of cereals; soil moisture, nitrogen supply, and light intensity. Soils which are dry or deficient in nitrogen, and high light intensities, favor a relatively greater development of the root system, i.e. high root/shoot ratio, whereas the reverse conditions--wet soils, high nitrogen, low light intensities lead to relatively low root/shoot ratios. Loomis et al. (1971), found in sugar beet that low night temperature and nitrogen deficiency restrict the growth of roots and tops, and concurrently the sucrose concentration in the storage root increased. Follet et al.

(1970) reported that N fertilization increased LAI (Leaf area index is the ratio of leaf area to ground area), LAD (Leaf area duration is the sum of the weekly average LAI's expressed as weeks), and the dry weight of crowns and petioles, but had little effect on NAR (Net assimilation rate is the increase in total dry weight per unit of leaf area per unit time expressed as $\text{g/m}^2/\text{day}$). Nitrogen decreased the sucrose percentage significantly and tended to reduce the ratio of roots to tops of the sugar beet plant.

Source-sink relations have been examined extensively using plants grown under optimal environmental conditions, in which external restraints acting on sink strength would be minimized. From these experiments, it can be concluded that source-sink ratio may be altered by (1) reducing the leaf area by partial defoliation or shading (i.e. decreasing the source-sink ratio); (2) removing physiological sinks such as fruits, apices or root tips (i.e. increasing the source-sink ratio). When source-sink ratios of whole plants are decreased, net photosynthetic and net assimilation rates of the remaining leaves increase (Maggs, 1964; Sweet and Wareing, 1966), suggesting that assimilate production is operating below its maximum potential. Increasing source-sink ratios tends to reduce the rate of assimilate accumulation (Sweet and Wareing, 1966), in some cases, the growth of remaining sinks, especially fruits (Maggs, 1963) has been observed to have increased. The latter

observation may be indicative of a source-limited situation and that sink strength was controlled by competition for some other factor in limiting supply.

Assuming that the proportionate rates of respiratory loss of assimilate are largely unaffected by changes in absolute rates of accumulation, then under conditions where the potential rate of production exceeds the rate of consumption, there must be some feedback mechanism whereby the rate of assimilation is regulated to meet the demand (Milthorpe and Moorby, 1969). The nature of such feedback control is not known. However, it would seem that the assimilation rate is not invariably dependent upon carbohydrate levels in leaves of some plants (Little and Loach, 1973). There is some evidence that both stomatal movement and levels of certain photosynthetic enzymes are affected by the supply of plant hormones to the leaves (Meidner, 1970; Wareing et al., 1969). Therefore, it is possible that photosynthetic rate may be under some control by hormonal factors synthesized in the sink regions and transported to the leaves.

Partition Within the Shoot System

The yield of a field crop depends on all that happens to it during its previous growth, and by how much yield can be increased. Apart from water, the economic yield of a crop consists mainly of carbon compounds, formed mainly by photosynthesis in leaves, and used in the growth of the plant organs that have economic value.

Although economic yield is correlated with total dry-matter yield, it does not necessarily continue to increase proportionally with increase in total dry weight, it may depend not only on how much photosynthate can be supplied to the economically useful parts of the plant, but also on how much photosynthate these parts are able to accept. The system that determines economic yield, therefore, consists of sources and sinks of photosynthate, that is, the leaves and the parts that have economic value. There is now much evidence that in some conditions the leaves can produce more photosynthate than the sink can receive, so that economic yield depends partly on the capacity of the sinks, and not wholly on the output of the photosynthetic system (Watson, 1971). Excess photosynthate may accumulate elsewhere in the plant, or its movement out of the leaves may be restricted, and in some species this slows photosynthesis. Thus the sink may sometimes regulate the rate of photosynthesis.

It seems obvious that such a productive system will operate most efficiently when the size and the structure of the crop canopy is such that light interception and CO_2 assimilation are maximal while the sinks are active, when the capacity of these sinks in storage organs or seeds is adequate to accept the photosynthate provided by the leaves, and when expenditure of dry matter on the rest of the plant (stems, petioles and roots) is no more than is necessary to support the leaves in an efficient arrangement and supply

sufficient mineral nutrients and water (Watson, 1971).

As a first approximation in understanding assimilate distribution, it is assumed that all assimilates irrespective of their positions of origin, move freely within the plant. However, it is well established that there is frequently a characteristic pattern of assimilate movement within the shoot system and that individual sinks may derive assimilates from specific groups of leaves. The developing wheat ear obtains most of its assimilates from the uppermost (flag) leaf, the lower leaves supplying little to the developing grains (Wardlaw, 1968). Under these conditions it is easy to envisage that source-sink relations may vary considerably within the shoot system, so that in some parts assimilate accumulation may be source-limited and in other parts sink-limited.

In most dicotyledonous plants net export commences when the leaf has reached between one-third and one-half its final area (Wardlaw, 1968). Initially, most of the assimilate exported from a young leaf is transported to the adjacent shoot apex. However, with time and the development of leaves above it, an increasingly greater proportion of its assimilates move to the roots. Thus, there is a fairly universal pattern of assimilate distribution within the whole plant. The lower leaves act as the main source of assimilates for roots, where as the upper leaves supply the shoot apex and leaves in an intermediate position may supply

assimilates in both directions. Defoliation experiments suggest that the pattern of assimilate movement is the net result of a complex interaction between the many sources and sinks (Thaine et al., 1959; Thrower, 1962). Furthermore, the physiological state of the source leaf influences the direction of assimilate movement in the stem; for example, both light and ATP treatment of leaves have been shown to increase the proportion of exported assimilate moved basipetally (Moorby, 1964; Shiroya, 1968).

The relation between sources and sinks of photosynthate in the sugar beet is still obscure. Cross-grafts between tops and roots of sugar beet and spinach beet showed that with both varieties, grafts of tops on spinach beet roots had a smaller net assimilation rate than grafts on the larger sugar beet roots (Thorne and Evans, 1964). Humphries and French (1969) found that sugar beet plants germinated in growth cabinets at 20°C and then transplanted into the field after 3 weeks developed much larger roots than plants grown from seeds drilled directly into the soil. The increased yield was mainly due to a sustained increase in photosynthesis because of the larger sink for carbohydrate provided by plants from the growth cabinets. Loach (1970) showed that cultivars with a larger root/shoot ratio maintained faster net assimilation rates during the latter stages of growth and hence produced greater yield than cultivars with a smaller ratio. Habeshaw (1973) reported

that the size and activity of sink for the product of photosynthesis exert a large measure of control over the carbohydrate level in the leaves. Winter and Mortimer (1967) found that the root does not exert a controlling influence on translocation, but that it can contribute to the efficiency of the process. Removal of the apex of growing sugar beet plants resulted in an immediate increase in growth of the storage root, suggesting that the apex either produced substances inhibitory to the root or competed with it for substrates (Das Gupta, 1972a).

The distribution of assimilates between the storage roots and leaves of sugar beet varies as the plant progresses through its ontogeny. In 50-day plants in the phase of leaf formation, the transport of assimilates to the roots is several-fold less intense than in 80 to 90-day plants in the phase of intense accumulation of sucrose in the roots. Later (110-120 days) the outflow of assimilates from the leaves again exhibits a sharp reduction, indicating the completion of the process of sugar accumulation (Kursanov, 1963). Much of the assimilates moving into the young leaves is converted into amino acids, while much of that entering the root is stored as sucrose. Sucrose appears to move against the concentration gradient from sieve tube to storage cell. In sugar beet, Fick et al. (1973) concluded that the partitioning priorities for photosynthate were respiration, top growth, fibrous root growth, and storage

root growth including sucrose accumulation. The rate of use by each sink was further regulated by its growth potential and by its environment. According to Trip (1969), in minor veins sugar is translocated in companion cells rather than in sieve tubes. In major veins translocation occurs in sieve tubes. Joy (1964), and Mortimer (1965) found that the restriction of movement of sucrose to the young leaf vertically above the root segment vertically below the exporting leaves appears to reflect simply differences in length of pathways rather than high resistance to lateral movement. Events in the petioles appear to play little part in controlling translocation (Mortimer, 1965; Swanson and Geiger, 1967), but competition between developing leaves and the storage root is of great importance.

Over and above the partitioning of exported assimilates into acropetal and basipetal moving streams, it has been found that assimilates from any one leaf are distributed among the competing sinks in strict patterns. In tobacco (Jones et al., 1959; Shiroya et al., 1961) and in sugar beet (Joy, 1964) there appears to be a preferential transport between leaves of the same orthostichy. In wheat the main source of assimilate imported by a young expanding leaf comes from the leaf two nodes below (Patrick, 1972a,b). This canalizing effect of the vascular system could have an important function in influencing the degree of competition between neighboring sinks. Therefore, the control of

partitioning of exported assimilate is complex, being influenced by factors within and beyond the source leaf.

The Mechanism of Assimilate Partitioning

The various growth and storage centers of the plant activity compete for assimilates and each center has a certain competitive or mobilizing ability, whereby it can pull or attract assimilates. The mobilizing ability will vary depending upon the rate of supply of assimilates and will reach its maximal potential only under condition of non-limiting supply.

The concept of mobilizing ability makes no assumption as to whether the role of the sink in transport is a purely passive one (i.e. an active transport system would determine the potential maximum rate of assimilate movement to the sink; under these conditions, the only control the sink may exert on transport as if its capacity to accumulate assimilates is less than the potential rate of movement) or whether it directly influences the rate and pattern of assimilate movement (i.e. movement depends upon the relative capacities of the sinks to withdraw assimilate from the transport system). The mechanism of phloem transport is important in relation with the mobilizing ability.

According to Crafts and Crisp (1971) the most accepted theory of phloem transport is the pressure flow (or mass flow) theory, where the flow of dissolved organic substances, depends upon a turgor pressure gradient along the path of

transport. The maintenance of this turgor pressure difference between the source and the sink will depend upon continual loading of sucrose into the phloem at the source, and its removal at the sink, either by metabolism or by compartmentation into storage materials.

On this hypothesis, it seems less likely that the loading of assimilates into the phloem at the source would be under direct control of the sink, but in so far as uptake at the sink ensures continued flow of assimilates toward it, the sink may be said to attract assimilates. Such a mechanism would ensure that assimilate is transported to a sink at a rate which is proportional to the rate of its consumption in growth and/or the storage of reserve materials, i.e. is proportional to its sink strength. When there is competition between sinks it is assumed that the competitive ability of any given growth center will depend upon its sink strength; that is to say, in terms of the mass flow theory, the mobilizing ability of a sink is determined by its capacity to accumulate assimilates.

Apart from the commonly accepted view of sink activity in relation to mass flow theory, there is increasing evidence suggesting that the hormone content of a growth center may affect its mobilizing ability for assimilates. Hew et al. (1967) showed that when IAA or GA was applied to decapitated soybean plants, the export of photosynthate from the primary leaves was increased. The applied IAA could be

recovered only from the stem, and it was concluded that it influenced translocation in the stem, having little effect on the processes of loading photosynthate into the sieve tubes. Mothes and Engelbrecht (1961) believe that kinetin directly influences the movement and accumulation of ^{14}C labelled amino acids independently of any effect arising from the stimulation of protein synthesis. Das Gupta (1972b) found that IAA, GA, and kinetin significantly increased the dry weight of sugar beet when all leaves were present, which was mainly explained by the large increase in root. The growth substances probably stimulated cambial activity and hence the mobilization of substrates resulting in a bigger root when a relatively large leaf area existed.

These observations raise the question as to the mechanism of hormone action stimulating assimilate movement to the sink. Seth and Wareing (1967), and Mullins (1970) concluded that one possibility is that hormones influence assimilate mobilization by regulating sink strength. When IAA was applied to a tissue segment, rates of metabolite accumulation (i.e. sink strength) in the treated area were enhanced. Increased assimilate movement into non-growing internodes of decapitated plants of Solanum andigena may be detected within 6 hours of IAA treatment to the cut surface of the stump (Booth et al., 1962).

The precise mechanism of these hormone-directed transport phenomena remain obscure. However, it is possible

that a high endogenous hormone content of a growing organ may play an important role in its mobilizing ability.

Apart from hormone, in soybean leaves Silvius et al. (1978) concluded that sucrose phosphate synthetase might have an important regulatory role in photosynthate partitioning and transport.

MATERIALS AND METHODS

The experiments reported on in this manuscript were all conducted at East Lansing, Michigan.

Experiment in 1975

Two experiments were conducted in 1975, one field and one pot experiment. Four sugar beet lines from two selections were used in both experiments, these lines were:

- (1) 1H5, seeds from the first cycle of selection, which have high TLWR
- (2) 1L1, seeds from the first cycle of selection, which have low TLWR
- (3) 2H4, seeds from the second cycle of selection, which have high TLWR
- (4) 2L18, seeds from the second cycle of selection, which have low TLWR

The experimental design for both the field and the pot experiment was a randomized block design with four treatments (lines as treatments) and three replications.

Field Experiment

The seeds were dibble planted by hand with a depth of 2.5 cm in a field experiment on May 14. The experimental

unit was a single-row plot which contained enough plants for each treatment for three harvests. The rows were 75 cm apart, plants spaced at 30 cm within each row. Thinning was done to one plant per seedball as uniformly as possible on June 1. The plots were hand hoed as needed to remove weeds not controlled by the herbicide. All plots were fertilized two times during the growing season. The first fertilization was done on June 19, and the second one on July 1 with 50 g of 12-12-12 ($\text{N}, \text{P}_2\text{O}_5, \text{K}_2\text{O}$) in 50 liters of water.

Samples for growth analysis from experimental plots were harvested three times during the growing season. The first samples were harvested on June 24, the second harvest on July 23, and the third harvest on September 4. Five plants were dug up at random per line per replication for each sample. The roots were washed free of soil and the plants separated into leaf blades, petioles, crowns, and tap roots. Fibrous roots were not harvested. Crowns were separated from the tap roots of the plants starting with the third harvest. The separation of the tops from the roots were made by cutting the plants at the junction of the roots and the leaf bases. The crowns were separated from the tap roots by cutting the green parts at the tops from the white tap roots. All plant parts were weighed immediately after separation, sliced into small pieces and put into paper sacks separately. Finally all plant parts were dried in ovens at 80°C . Complete drying took about 5

days.

Data were obtained on percent germination; fresh and dry matter accumulation of total plants, various plant parts, and the ratios of various plant parts. Dry matter was not obtained for the first harvest.

Average data of fresh and dry matter accumulation per plant, various plant parts, and the ratio of various plant parts were analyzed statistically by the procedure of analysis of variance and the associated tests of significance and comparisons. Steel and Torrie (1960) was used as a reference for the statistical analysis of the data and methods used for calculation of the various statistics used in this study.

Pot Experiment Outdoors

The seeds were planted at a depth of 2.5 cm in vermiculite in pots outdoors on May 10. Three sizes of pots were used in this experiment: (1) 15 cm pots for plants 22-25 days after emergence, (2) 27 cm pots for plants 40-50 and 60-70 days after emergence, and (3) 45 cm pots (tiles 60 cm deep) for plants 90-100 days after emergence. The experimental unit was 2 rows of pots and consisted of 16 plants. The plants were thinned to one per pot on May 22, and supplied with 1-2 liters nutrient solution daily containing Ca, K, NH_4 , Mg, Fe, NO_3 , Cl, H_2PO_4 , SO_4 ions and trace elements. Weedings were done by hand, pests and diseases were

controlled as needed.

Samples for growth analysis were harvested four times during the growing season. The first samples were harvested on June 17, second on July 18, third on August 17, and fourth on September 16. Three plants were harvested per line per replication for each harvest. In this pot experiment fibrous roots were harvested. The vermiculite was watered, the plants plus vermiculite were carefully removed from the pots. The tap roots plus fibrous roots were washed free of vermiculite by running tap water through a rubber hose above an aluminum screen. The fibrous roots were then separated from the tap roots by cutting, the broken fibrous roots were collected from the pots and the aluminum screen for the weight determination. The separation of crowns from the plants starting with the third harvest.

The method of separation of other various plant parts, drying, and data analysis were similar as in the field experiment.

Experiment in 1976

Two experiments were conducted in 1976, one growth chamber and one field experiment. A randomized block design was used in both experiments with four treatments and three replications.

Growth Chamber Experiment

Treatments were four sugar beet lines (1H5, 1L1, 2H4, and 2L18) as in 1975. The seeds were planted in vermiculite in 15 cm pots in a growth chamber on January 12, and seedlings were thinned to one per pot on January 20. The plants were watered daily with nutrient solution at the temperature of 24°C. The chamber conditions were 65% relative humidity, with light intensity of between 320-420 microEinsteins m⁻² sec⁻¹ at the plant canopy top for 14 hours each day. All plants were harvested on February 12. The roots were washed free of vermiculite and the plants separated into leaf blades, petioles, and tap roots. Fibrous roots were not recovered.

Field Experiment

Two sugar beet lines used in the previous experiment (2H4 and 2L18) and two commercial sugar beet hybrids (US H20 and US H21) were grown in this experiment. The seeds were planted on May 22, and seedlings thinned to one plant per location on June 8. Samples from experimental plots were harvested three times during the growing season; on July 3, August 1, and September 10.

The field work and the data obtained for growth analysis were similar as in 1975, except at the third harvest five additional plants were dug up per line/hybrid per replication and sent to the Bean-Beet Research Farm and Michigan Sugar Laboratory at Saginaw for sugar analysis.

Field Experiment in 1977

Seeds were planted in a field experiment on May 18, and seedlings thinned to one per seed location on June 3. The experiment was designed as a randomized block design with four treatments and five replications. Four sugar beet lines were used; two from each cycle of selection. The lines were 1H1, 1L6, 2H2, and 2L6. The experimental plots were harvested five times during the growing season; June 20, July 12, August 2, August 23, and September 12. Five plants were dug up at random per line per replication at each harvest. Crowns were separated from the plants starting with the third harvest. Fibrous roots were not harvested.

The field work and the data obtained for growth analysis were similar as in 1975.

RESULTS AND DISCUSSION

1975 Field Experiment

Percent Emergence: In the field experiment 33 seeds were planted for each line for each replication on May 14. Most seedlings emerged between May 22 and May 24. The emergence data are presented in Table 1.

Table 1. The number of seedlings emerged and the percent of emergence of four sugar beet lines at East Lansing in 1975 field experiment

Line	Replication			Total Emerged	Percent Emergence
	1	2	3		
1H5	18	24	24	66	66.67
1L1	21	24	20	65	65.66
2H4	25	23	27	75	75.76
2L18	20	24	20	64	64.65

Table 1 shows that 2L18 had the lowest and 2H4 the highest percent emergence. From visual observation 1H5 and 2H4 have smaller leaves and the leaves were more vertically oriented.

Fresh and Dry Matter Production: Table 2 shows the fresh and the dry weight of total plant and of separate

plant parts for each harvest for each line. Fresh and dry weight of total plant (excludes fibrous roots) was not significantly different at each harvest. Fresh leaf blades weight was significantly different at the first and the third harvest, whereas dry leaf blades weight was significantly different only at the third harvest. At the first harvest 2L18 had significantly higher fresh weight of leaf blades than 1H5, 1L1, and 2H4. At the third harvest 1L1 and 2L18 had significantly higher fresh weight of leaf blades than 2H4; 2H4 had the lowest dry weight of leaf blades and differed significantly from 1H5, 1L1, and 2L18.

Various parameters such as leaf blades, petioles, etc. are important when a new production practice is being evaluated; however, the final tap root yield of sugar beet is of primary consideration. The fresh weight of 2L18 tap root was significantly greater from the other three lines only at the first harvest.

There were no significant differences in fresh and in dry weight of petioles at the first and the second harvest. At the third harvest 2L18 had significantly higher fresh weight of petioles than 1H5 and 2H4, and had significantly higher dry weight of petioles than 1H5, 1L1, and 2H4.

Crown represents the stem and hypocotyl but the division between crown and tap root was judged by eye and crown weight is subject to greater error than other parts. In

Table 2. Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1975 field experiment.

Line	Total g/plant		Leaf blades g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	20.02 a ^{4/}	--	11.69 a ^{4/}	--
1L1	18.62 a	--	9.47 a	--
2H4	12.43 a	--	8.46 a	--
2L18	24.58 a	--	16.95 b	--
Second Harvest ^{2/}				
1H5	416.88 a	53.35 a	165.15 a	22.07 a
1L1	347.89 a	42.13 a	150.99 a	19.03 a
2H4	251.04 a	37.58 a	92.94 a	14.77 a
2L18	359.05 a	48.59 a	125.51 a	50.21 a
Third Harvest ^{3/}				
1H5	1576.57 a	192.30 a	407.94 ab	53.01 b
1L1	1617.91 a	187.54 a	428.89 b	50.83 b
2H4	1407.41 a	167.48 a	327.63 a	37.87 a
2L18	1818.14 a	215.89 a	477.74 b	60.37 b

^{1/} The first harvest (age 33 days) was taken on June 24.

^{2/} The second harvest (age 62 days) was taken on July 23.

^{3/} The third harvest (age 103 days) was taken on September 4.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 2 (Continued). Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1975 field experiment.

Line	Tap root g/plant		Petioles g/plant		Crown g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	1.99 ab ^{4/}	--	6.35 a ^{4/}	--	--	--
1L1	1.28 a	--	7.87 a	--	--	--
2H4	1.59 a	--	2.39 a	--	--	--
2L18	2.68 b	--	4.95 a	--	--	--
Second Harvest ^{2/}						
1H5	162.07 a	22.77 a	89.65 a	8.50 a	--	--
1L1	120.81 a	15.63 a	76.09 a	7.47 a	--	--
2H4	104.37 a	17.08 a	53.76 a	5.73 a	--	--
2L18	147.25 a	20.20 a	82.30 a	8.18 a	--	--
Third Harvest ^{3/}						
1H5	803.97 a	100.37 a	282.32 a	26.82 a	81.84 a	12.10 a
1L1	779.70 a	92.96 a	313.32 ab	29.77 a	96.00 a	13.97 a
2H4	763.65 a	94.30 a	227.31 a	22.06 a	88.61 a	13.22 a
2L18	854.50 a	104.79 a	387.20 b	35.83 b	98.69 a	14.90 a

^{1/} The first harvest (age 33 days) was taken on June 24.

^{2/} The second harvest (age 62 days) was taken on July 23.

^{3/} The third harvest (age 103 days) was taken on September 4.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

this field experiment crown had formed when the third samples were taken, and no significant differences between lines were obtained in the fresh and the dry weights of crown.

The Ratio of Various Plant Parts: Table 3 shows the ratio of various plant parts of four sugar beet lines for each harvest in the 1975 field experiment.

The fresh tap root/leaf blades ratio was significantly different only at the first harvest, 2H4 had the highest and 1L1 had the lowest fresh tap root/leaf blades ratio. At the third harvest there was a trend that 1H5 and 2H4 to have higher fresh and dry tap root/leaf blades ratios. The tap root/leaf blades ratio of each line increased as the plant aged.

There were no significant differences in the fresh and in the dry petioles/leaf blades ratios at each harvest.

The dry tap root/petioles ratio was significantly different only at the third harvest, no significant differences were obtained in fresh tap root/petioles at each harvest. At the third harvest 2H4 had significantly higher dry tap root/petioles ratio than 1L1 and 2L18.

The fresh tap root/total plant ratio differed significantly at the first harvest only, no significant differences were obtained in the fresh and in the dry tap root/total plant ratios at the other harvests. At the first harvest 1L1 had the lowest fresh tap root/total plant ratio and

Table 3. The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 field experiment.

Line	Tap root/Leaf blades g/g/plant		Petioles/Leaf blades g/g/plant		Tap root/Peti- oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	0.16 b ^{4/}	--	0.26 a ^{4/}	--	0.49 a ^{4/}	--
1L1	0.14 a	--	0.26 a	--	0.26 a	--
2H4	0.20 c	--	0.29 a	--	0.67 a	--
2L18	0.15 ab	--	0.29 a	--	0.54 a	--
Second Harvest ^{2/}						
1H5	1.03 a	1.06 a	0.53 a	0.36 a	2.03 a	2.88 a
1L1	0.78 a	0.79 a	0.50 a	0.38 a	1.58 a	2.09 a
2H4	1.03 a	1.15 a	0.58 a	0.39 a	1.99 a	3.02 a
2L18	1.18 a	0.99 a	0.63 a	0.40 a	1.76 a	2.46 a
Third Harvest ^{3/}						
1H5	2.08 a	1.88 a	0.70 a	0.50 a	2.92 a	3.87 ab
1L1	1.78 a	1.80 a	0.71 a	0.57 a	2.57 a	3.24 a
2H4	2.52 a	2.43 a	0.70 a	0.54 a	3.47 a	4.36 b
2L18	1.87 a	1.80 a	0.82 a	0.60 a	2.32 a	3.02 a

^{1/} The first harvest (age 33 days) was taken on June 24.

^{2/} The second harvest (age 62 days) was taken on July 23.

^{3/} The third harvest (age 103 days) was taken on September 4.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 3 (Continued). The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 field experiment.

Line	Tap root/Total plant g/g/plant		Crown/Leaf blades g/g/plant		Crown/Peti-oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	0.10 ab ^{4/}	--	--	--	--	--
1L1	0.07 a	--	--	--	--	--
2H4	0.14 a	--	--	--	--	--
2L18	0.11 b	--	--	--	--	--
Second Harvest ^{2/}						
1H5	0.40 a	0.44 a	--	--	--	--
1L1	0.35 a	0.37 a	--	--	--	--
2H4	0.42 a	0.45 a	--	--	--	--
2L18	0.40 a	0.41 a	--	--	--	--
Third Harvest ^{3/}						
1H5	0.51 a	0.52 a	0.21 a	0.24 a	0.30 a	0.46 a
1L1	0.48 a	0.50 a	0.22 a	0.27 a	0.31 ab	0.46 a
2H4	0.54 a	0.57 a	0.31 a	0.35 a	0.42 b	0.61 b
2L18	0.47 a	0.49 a	0.22 a	0.26 a	0.26 a	0.41 a

^{1/} The first harvest (age 33 days) was taken on June 24.

^{2/} The second harvest (age 62 days) was taken on July 23.

^{3/} The third harvest (age 103 days) was taken on September 4.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

differed significantly from 2H4 and 2L18.

There were no significant differences in the fresh and in the dry crown/leaf blades ratios. On the other hand, there were significant differences in the fresh and in the dry crown/petioles ratio. 2H4 had significantly higher fresh crown/petioles ratio than 1H5 and 2L18, and significantly higher dry crown/petioles ratio than 1H5, 1L1 and 2L18.

Partition of Assimilates: Table 4 shows the partition of assimilates of four sugar beet lines for each harvest in 1975 field experiment.

The partition of assimilates into leaf blades and petioles decreased with each successive harvest, on the other hand, the partition of assimilates into crown and tap root increased with age.

At the first harvest 2H4 and 2L18 had higher percentage of leaf blades, lower percentage of petioles, and higher percentage of tap root.

At the second harvest 1L1 had higher leaf blades percentage, but lower tap root percentage. No clear cut trends were apparent from partition of assimilates into petioles.

At the third harvest there was a trend that 1H5 and 2H4 have lower leaf blades, lower petioles, but higher tap root percentage. No clear cut trends were obtained in the partition of assimilates into crown. The highest percentage

Table 4. Partition of assimilates (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 field experiment.

Line	Leaf blades Percent		Petioles Percent		Tap root Percent		Crown Percent	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}								
1H5	58.29	--	31.38	--	10.33	--	--	--
1L1	50.74	--	42.26	--	7.00	--	--	--
2H4	66.18	--	20.16	--	13.66	--	--	--
2L18	68.86	--	20.14	--	11.00	--	--	--
Second Harvest ^{2/}								
1H5	39.22	41.37	21.12	15.33	39.66	43.50	--	--
1L1	43.46	45.19	21.87	17.79	34.67	37.02	--	--
2H4	37.02	39.30	21.31	15.37	41.67	45.33	--	--
2L18	36.67	41.79	22.99	16.93	40.33	41.27	--	--
Third Harvest ^{3/}								
1H5	25.87	27.50	17.94	13.88	51.00	52.33	5.19	6.29
1L1	26.51	27.10	19.30	15.87	48.33	49.67	5.86	7.36
2H4	23.28	22.51	16.15	13.12	54.33	56.67	6.24	7.70
2L18	26.28	27.96	21.30	16.60	47.00	48.67	5.42	6.77

^{1/} The first harvest (age 33 days) was taken on June 24.

^{2/} The second harvest (age 62 days) was taken on July 23.

^{3/} The third harvest (age 103 days) was taken on September 4.

of dry tap root was 56.67 percent (2H4), this was low compared to 63 percent as reported by Watson (1971), probably for older plants, however.

1975 Pot Experiment Outdoors

Percent Emergence: In the pot experiment 16 seeds were planted for each line for each replication on May 10. Most seedlings emerged between May 15 and May 17. The result on percent emergence is presented in Table 5.

Table 5. The number of seedlings emerged and the percent of emergence of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Replication			Total Emerged	Percent Emergence
	1	2	3		
1H5	16	15	16	47	97.92
1L1	16	16	14	46	95.83
2H4	16	16	15	47	97.92
2L18	15	15	16	46	95.83

Table 5 shows that all lines had high percent emergence. In the pot experiment higher percent emergence and better plant stands were obtained compared with the field experiment.

Fresh and Dry Matter Production: Table 6 shows the fresh and the dry weight of total plant and of different plant parts of four sugar beet lines at each harvest in

1975 pot experiment outdoors.

There were no significant differences in the fresh and in the dry weight of total plant at each harvest (Table 6 and Figure 1).

The dry weight of tap root was significantly different at the second and the third harvest, while the fresh weight of tap root was significantly different only at the third harvest. At the second harvest 1L1 had significantly lower dry weight of tap root than 1H5, 2H4, and 2L18. At the third harvest 1H5 and 2H4 had significantly higher fresh and dry weight of tap root than 1L1 and 2L18 (Table 6 and Figure 2).

The fresh weight of leaf blades was significantly different at the second and the third harvest, while the dry weight of leaf blades was significantly different only at the third harvest. At the second harvest 1L1 and 2L18 had significantly higher fresh weight of leaf blades than 2H4. At the third harvest 1H5, 1L1, and 2L18 had significantly higher fresh and dry weights of leaf blades than 2H4. 2H4 had the lowest fresh and dry weight of leaf blades at the last three harvests (Table 6 and Figure 3).

The fresh weight of petioles differed significantly at the second and the fourth harvest, while the dry weight of petioles was significantly different only at the second harvest. At the second harvest 2L18 had significantly higher fresh and dry weights of petioles than 1H5, 1L1,

Table 6. Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Total g/plant		Tap root g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	39.40 a ^{5/}	3.68 a ^{5/}	3.39 a ^{5/}	0.38 a ^{5/}
1L1	24.39 a	2.43 a	1.42 a	0.23 a
2H4	27.17 a	3.32 a	2.54 a	0.29 a
2L18	36.73 a	3.10 a	1.91 a	0.19 a
Second Harvest ^{2/}				
1H5	695.97 a	77.59 a	306.11 a	37.83 b
1L1	630.94 a	67.90 a	208.99 a	26.59 a
2H4	602.28 a	73.91 a	285.83 a	38.90 b
2L18	791.03 a	81.48 a	264.85 a	33.95 b
Third Harvest ^{3/}				
1H5	1718.39 a	202.03 a	882.14 b	108.40 c
1L1	1738.14 a	188.54 a	781.41 a	84.26 a
2H4	1618.20 a	181.73 a	868.53 b	97.25 b
2L18	1637.32 a	186.82 a	728.40 a	86.69 a
Fourth Harvest ^{4/}				
1H5	3704.05 a	458.47 a	2005.30 a	261.88 a
1L1	3460.81 a	422.42 a	1725.40 a	219.28 a
2H4	3096.85 a	396.65 a	1763.09 a	234.32 a
2L18	3851.46 a	467.61 a	1918.44 a	246.00 a

- 1/ The first harvest (age 33 days) was taken on June 17.
 2/ The second harvest (age 64 days) was taken on July 18.
 3/ The third harvest (age 94 days) was taken on August 17.
 4/ The fourth harvest (age 124 days) was taken on Sept. 16.
 5/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 6 (Continued). Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Leaf blades g/plant		Petioles g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	22.72 a ^{5/}	2.45 a ^{5/}	5.20 a ^{5/}	0.41 a ^{5/}
1L1	14.63 a	1.56 a	3.49 a	0.26 a
2H4	16.05 a	1.80 a	4.25 a	0.36 a
2L18	22.61 a	2.16 a	4.70 a	0.35 a
Second Harvest ^{2/}				
1H5	213.41 ab	24.21 a	119.59 a	10.42 a
1L1	228.56 b	25.19 a	135.21 a	10.91 a
2H4	159.65 a	21.02 a	119.97 a	10.25 a
2L18	272.77 b	27.67 a	182.50 b	13.95 b
Third Harvest ^{3/}				
1H5	383.11 b	46.85 b	272.02 a	22.72 a
1L1	413.28 b	50.67 b	357.72 a	31.09 a
2H4	282.69 a	36.22 a	274.93 a	23.52 a
2L18	396.46 b	46.07 b	337.38 a	31.20 a
Fourth Harvest ^{4/}				
1H5	735.75 a	90.38 a	604.66 ab	53.24 a
1L1	752.99 a	96.16 a	683.54 b	61.63 a
2H4	553.59 a	72.71 a	502.59 a	45.72 a
2L18	800.31 a	90.05 a	718.08 b	66.17 a

^{1/} The first harvest (age 33 days) was taken on June 17.

^{2/} The second harvest (age 64 days) was taken on July 18.

^{3/} The third harvest (age 94 days) was taken on August 17.

^{4/} The fourth harvest (age 124 days) was taken on Sept. 16.

^{5/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 6 (Continued). Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Fibrous roots g/plant		Crown g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	7.93 a ^{5/}	0.43 a ^{5/}	--	--
1L1	4.85 a	0.38 a	--	--
2H4	4.44 a	0.27 a	--	--
2L18	7.51 a	0.42 a	--	--
Second Harvest ^{2/}				
1H5	56.84 a	5.13 a	--	--
1L1	58.17 a	5.21 a	--	--
2H4	36.90 a	3.74 a	--	--
2L18	64.24 a	5.91 a	--	--
Third Harvest ^{3/}				
1H5	72.28 a	9.85 a	108.85 a	14.41 a
1L1	79.44 a	9.17 a	106.29 a	13.34 a
2H4	68.95 a	8.88 a	123.10 a	15.86 a
2L18	75.69 a	9.78 a	99.39 a	13.08 a
Fourth Harvest ^{4/}				
1H5	132.66 b	16.06 bc	226.06 b	36.80 b
1L1	116.34 b	12.99 b	182.53 a	32.34 a
2H4	50.95 a	6.95 a	226.73 b	36.77 b
2L18	155.77 b	19.37 c	258.86 b	40.02 b

1/ The first harvest (age 33 days) was taken on June 17.

2/ The second harvest (age 64 days) was taken on July 18.

3/ The third harvest (age 94 days) was taken on August 17.

4/ The fourth harvest (age 124 days) was taken on Sept. 16.

5/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

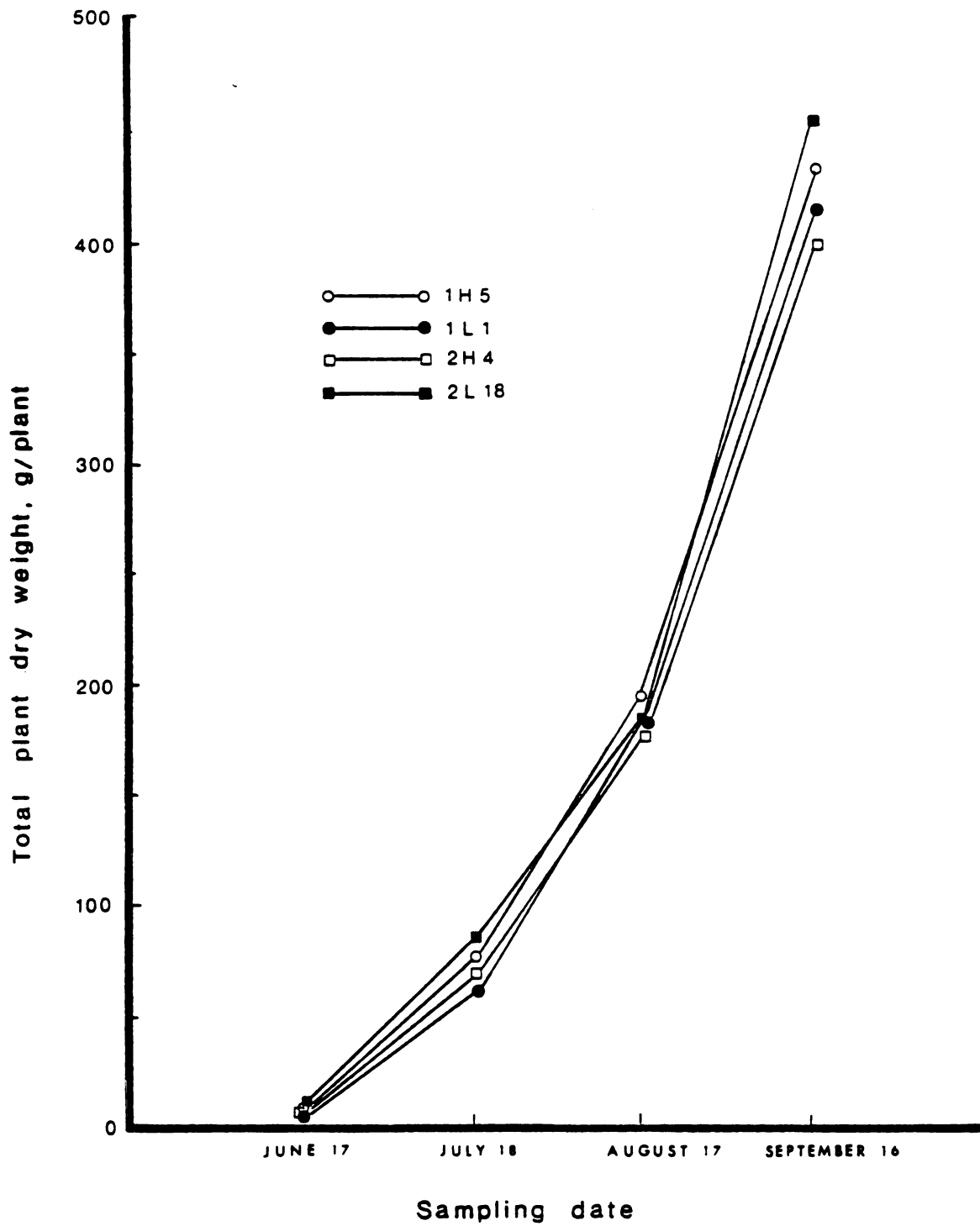


Figure 1. Changes in dry weight of total plant of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

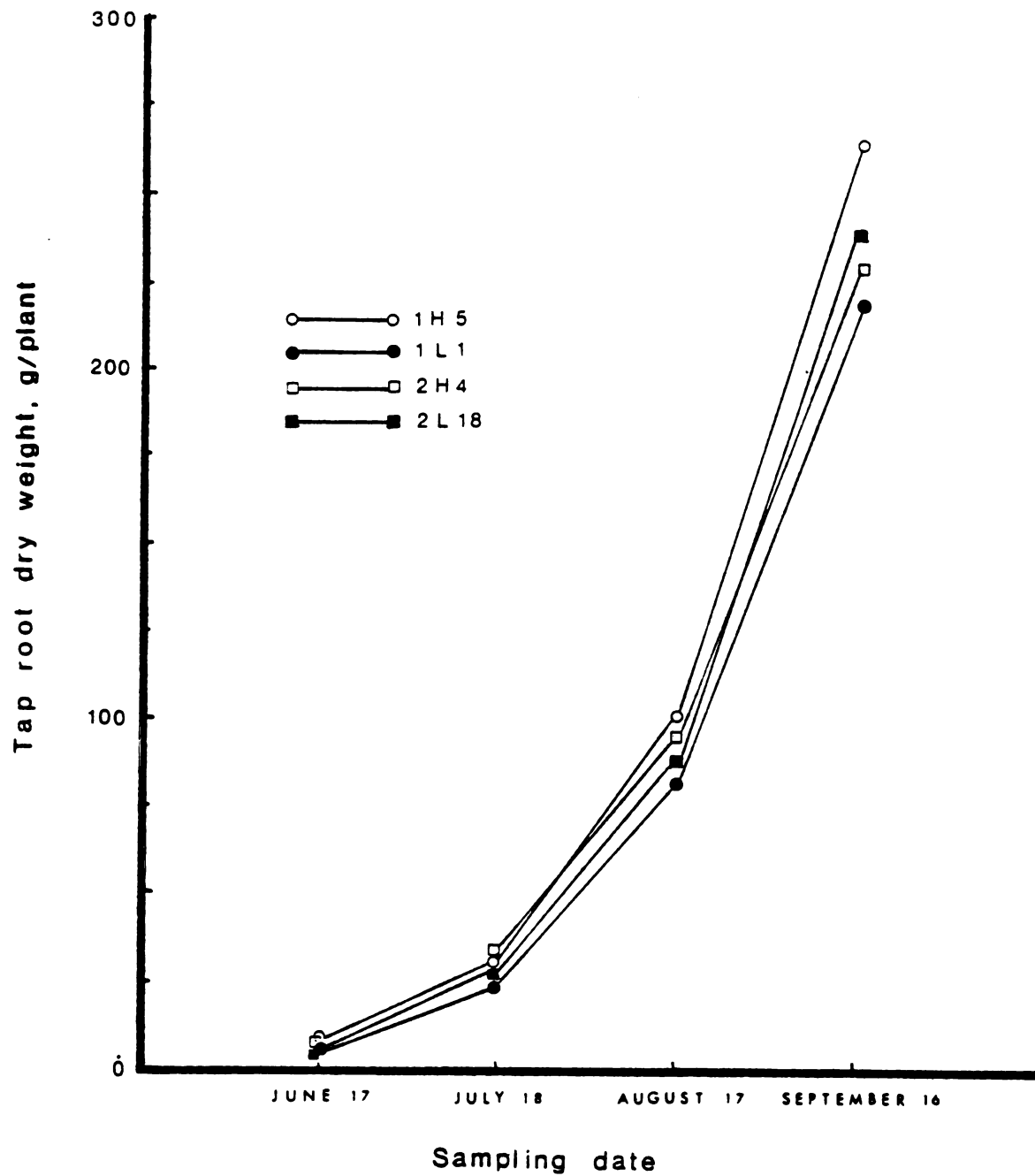


Figure 2. Changes in dry weight of tap root of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

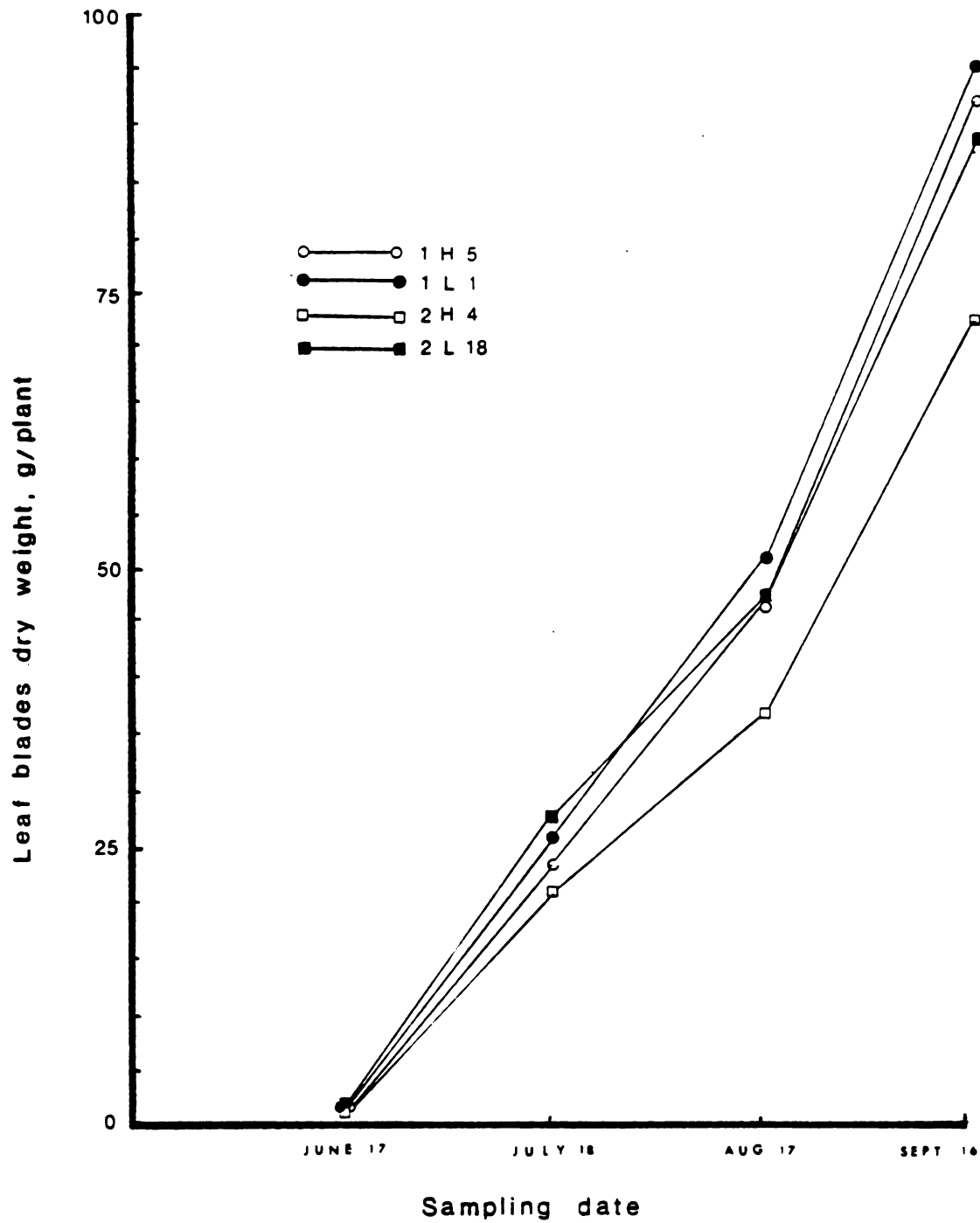


Figure 3. Changes in dry weight of leaf blades of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

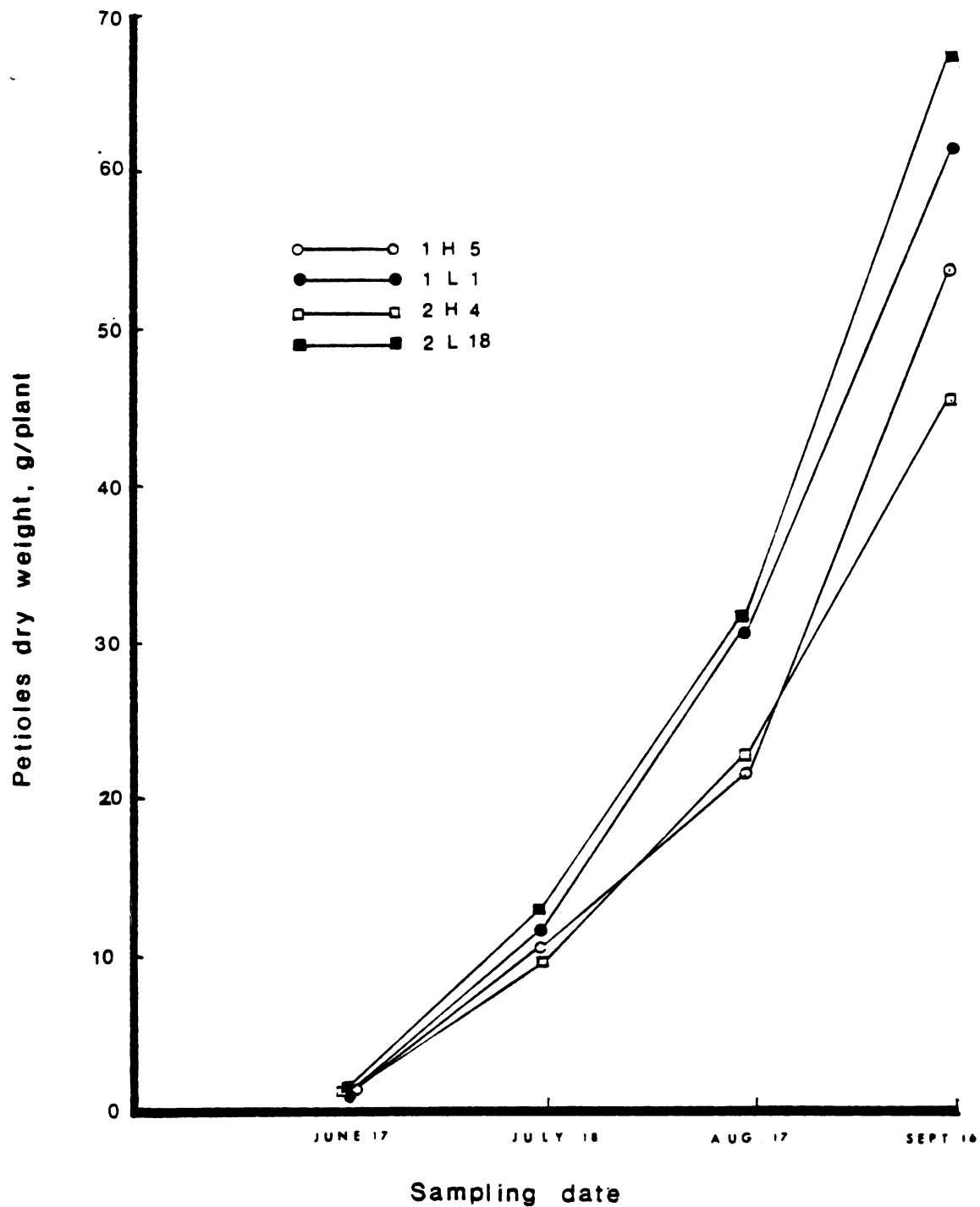


Figure 4. Changes in dry weight of petioles of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

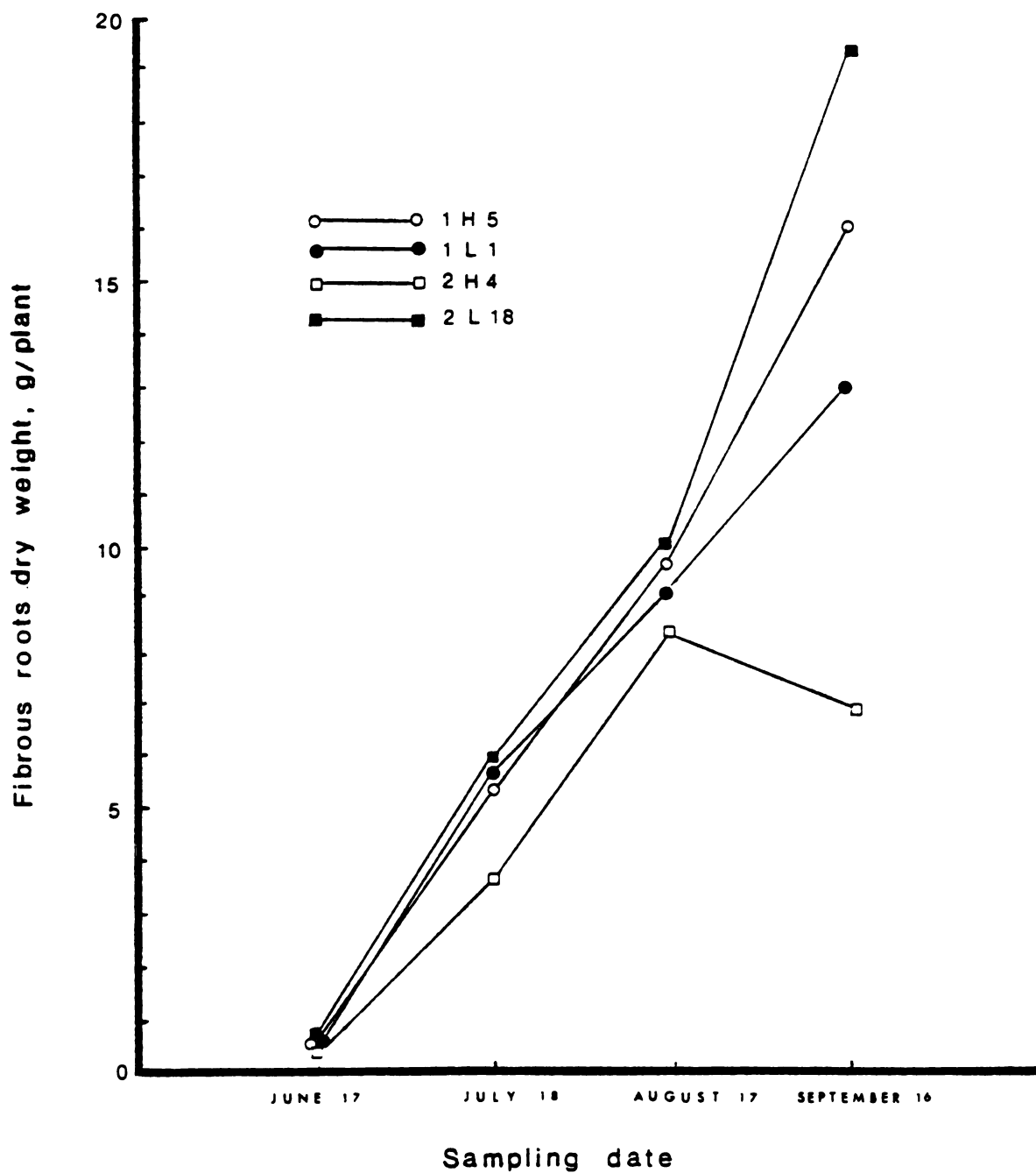


Figure 5. Changes in dry weight of fibrous roots of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

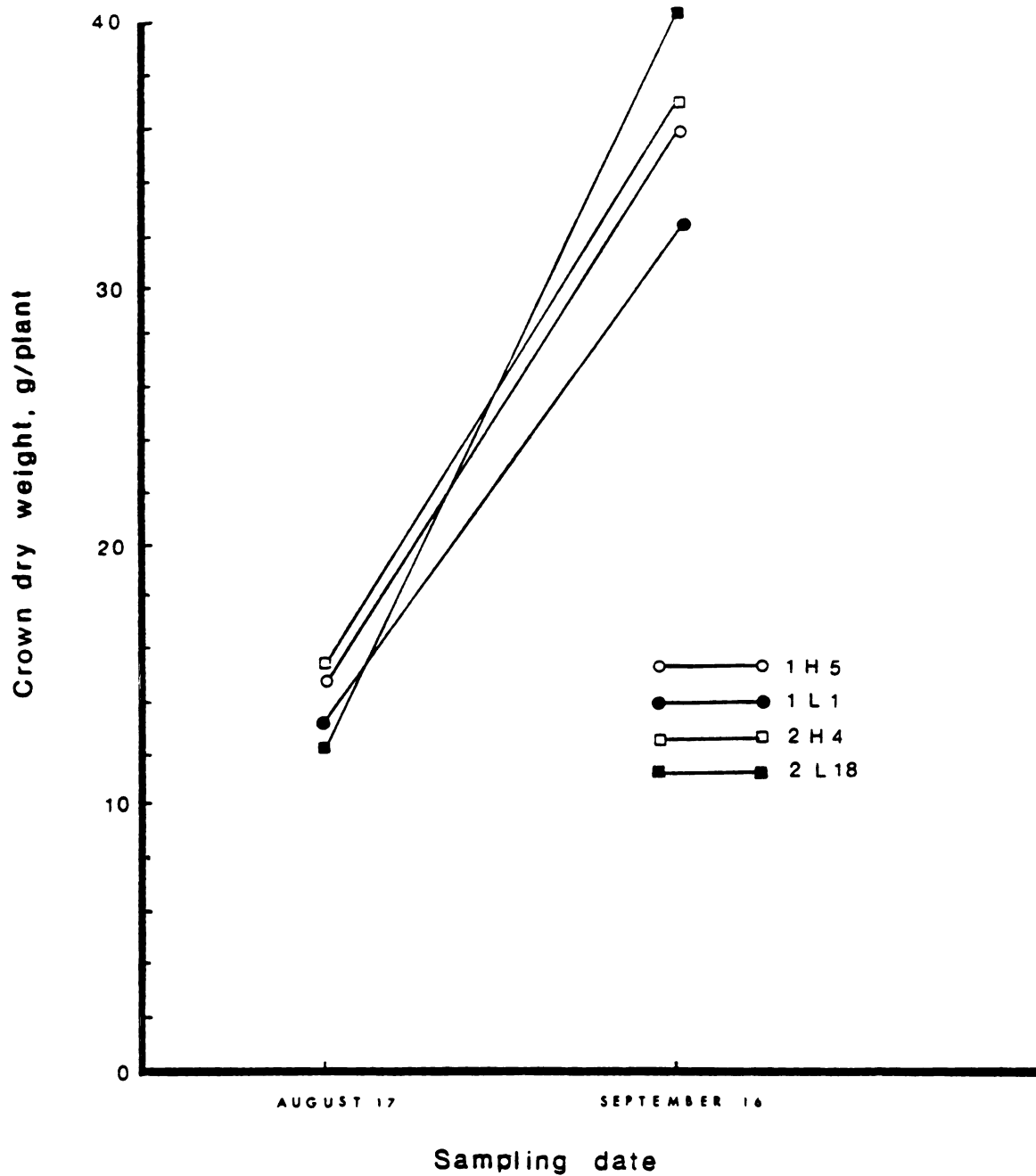


Figure 6. Changes in dry weight of crown of four sugar beet lines during the growing season at East Lansing in 1975 pot experiment outdoors.

and 2H4. At the fourth harvest 1L1 and 2L18 had significantly higher fresh weight of petioles than 2H4. 1L1 and 2L18 showed higher fresh and dry weights of petioles than the two high lines at the last three harvest (Table 6 and Figure 4).

The fresh and the dry weights of fibrous roots were significantly different only at the fourth harvest. 2H4 had the lowest fresh and dry weight of fibrous roots. Thorne et al. (1967) reported a dry weight value of 9 g plant⁻¹ at 76 days followed by a decline in maximum dry weight of fibrous roots to 6 g plant⁻¹. There is no indication for such a decline for 1H5, 1L1, and 2L18, except for 2H4 (Table 6 and Figure 5).

Significant differences were obtained in the fresh and in the dry weights of crown at the fourth harvest only. 1H5, 2H4, and 2L18 had significantly higher fresh and dry weights of crown than 1L1 (Table 6 and Figure 6).

The Ratio of Various Plant Parts: Table 7 shows the ratio of various plant parts of four sugar beet lines at each harvest in the 1975 pot experiment outdoors.

There were significant differences in the fresh and in the dry tap root/leaf blades ratios at each harvest. For the first three harvests, 1H5 and 2H4 had the highest fresh and dry tap root/leaf blades ratios. At the fourth harvest 2H4 had significantly higher fresh tap root/leaf blades ratio than 1H5, 1L1, and 2L18; 2H4, 1H5 and 2L18 had

significantly higher dry tap root/leaf blades ratio than 1L1.

The fresh and the dry petioles/leaf blades ratios were significantly different only at the second and the third harvests. At the second harvest 2H4 and 2L18 had the highest fresh and dry petioles/leaf blades ratios. At the third harvest 1L1, 2H4, and 2L18 had significantly higher fresh petioles/leaf blades ratios than 1H5; 1L1 and 2H4 had significantly higher dry petioles/leaf blades ratios than 1H5.

The fresh tap root/petioles ratio was significantly different at each harvest, but the dry tap root/petioles ratio differed significantly only at the second and the third harvest. At all four harvests 1H5 and 2H4 had significantly higher fresh tap root/petioles ratios. The same result was obtained at the second and the third harvests for dry tap root/petioles ratio.

The fresh tap root/total plant ratio was significantly different at each harvest, but the dry tap root/total plant ratio differed significantly only at the last three harvests. At the first, the second, and the fourth harvest 1H5 and 2H4 had significantly higher fresh tap root/total plant ratio than 1L1 and 2L18, but at the third harvest only 2H4 differed significantly in fresh tap root/total plant ratio from 1L1 and 2L18. At the second and the third harvest 1H5 and 2H4 had significantly higher dry tap root/

Table 7. The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Tap root/Leaf blades g/g/plant		Petioles/Leaf blades g/g/plant		Tap root/Peti- oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	0.14 b ^{5/}	0.15 b ^{5/}	0.22 a ^{5/}	0.17 a ^{5/}	0.65 b ^{5/}	0.92 a ^{5/}
1L1	0.09 a	0.09 a	0.22 a	0.17 a	0.41 a	0.88 a
2H4	0.16 b	0.16 b	0.26 a	0.19 a	0.59 b	0.77 a
2L18	0.08 a	0.09 a	0.20 a	0.15 a	0.40 a	0.57 a
Second Harvest ^{2/}						
1H5	1.45 b	1.63 b	0.56 a	0.42 a	2.58 b	3.66 b
1L1	0.92 a	1.13 a	0.59 a	0.43 a	1.56 a	2.44 a
2H4	1.83 c	1.86 b	0.75 c	0.49 b	2.43 b	3.78 b
2L18	0.97 a	1.23 a	0.67 b	0.50 b	1.45 a	2.44 a
Third Harvest ^{3/}						
1H5	2.32 b	2.41 b	0.71 a	0.50 a	3.26 b	4.82 b
1L1	1.94 ab	1.80 a	0.87 b	0.65 b	2.22 a	2.74 a
2H4	3.12 c	2.70 c	0.97 c	0.66 b	3.16 b	4.14 b
2L18	1.89 a	1.92 a	0.86 b	0.57 ab	2.20 a	2.86 a
Fourth Harvest ^{4/}						
1H5	2.74 a	2.93 bc	0.82 a	0.58 a	3.33 b	4.99 a
1L1	2.24 a	2.31 a	0.85 a	0.65 a	2.53 a	3.62 a
2H4	3.33 b	3.28 c	0.92 a	0.62 a	3.58 b	5.28 a
2L18	2.46 a	2.58 b	0.91 a	0.67 a	2.68 a	3.73 a

1/ The first harvest (age 33 days) was taken on June 17.

2/ The second harvest (age 64 days) was taken on July 18.

3/ The third harvest (age 94 days) was taken on August 17.

4/ The fourth harvest (age 124 days) was taken on Sept. 16.

5/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 7 (Continued). The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Tap root/Total plant g/g/plant		Fibrous roots/ Leaf blades g/g/plant		Fibrous roots/ Total plant g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	0.09 b ^{5/}	0.10 a ^{5/}	0.35 a ^{5/}	0.18 a ^{5/}	0.20 a ^{5/}	0.12 a ^{5/}
1L1	0.06 a	0.09 a	0.29 a	0.21 a	0.20 a	0.15 a
2H4	0.09 b	0.10 a	0.28 a	0.15 a	0.16 a	0.10 a
2L18	0.05 a	0.06 a	0.32 a	0.19 a	0.20 a	0.14 a
Second Harvest ^{2/}						
1H5	0.44 b	0.49 b	0.28 a	0.21 a	0.08 b	0.06 ab
1L1	0.33 a	0.39 a	0.26 a	0.24 a	0.09 b	0.08 b
2H4	0.47 b	0.53 b	0.24 a	0.18 a	0.06 a	0.05 a
2L18	0.34 a	0.42 a	0.23 a	0.21 a	0.08 b	0.07 b
Third Harvest ^{3/}						
1H5	0.51 ab	0.54 b	0.20 a	0.21 a	0.04 a	0.05 a
1L1	0.45 a	0.44 a	0.19 a	0.20 a	0.05 a	0.05 a
2H4	0.54 b	0.53 b	0.24 a	0.24 a	0.04 a	0.05 a
2L18	0.45 a	0.46 a	0.19 a	0.21 a	0.05 a	0.05 a
Fourth Harvest ^{4/}						
1H5	0.55 b	0.54 a	0.18 bc	0.18 bc	0.04 b	0.04 bc
1L1	0.50 a	0.52 a	0.14 ab	0.13 ab	0.04 b	0.03 b
2H4	0.57 b	0.59 b	0.10 a	0.09 a	0.02 a	0.02 a
2L18	0.50 a	0.53 a	0.19 c	0.23 c	0.04 b	0.04 c

1/ The first harvest (age 33 days) was taken on June 17.

2/ The second harvest (age 64 days) was taken on July 18.

3/ The third harvest (age 94 days) was taken on August 17.

4/ The fourth harvest (age 124 days) was taken on Sept. 16.

5/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 7 (Continued). The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Crown/Leaf blades g/g/plant		Crown/Peti- oles g/g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	--	--	--	--
1L1	--	--	--	--
2H4	--	--	--	--
2L18	--	--	--	--
Second Harvest ^{2/}				
1H5	--	--	--	--
1L1	--	--	--	--
2H4	--	--	--	--
2L18	--	--	--	--
Third Harvest ^{3/}				
1H5	0.29 a	0.32 a	0.40 a	0.64 a
1L1	0.26 a	0.28 a	0.30 a	0.44 a
2H4	0.43 b	0.34 a	0.45 a	0.68 a
2L18	0.25 a	0.28 a	0.30 a	0.43 a
Fourth Harvest ^{4/}				
1H5	0.32 b	0.41 ab	0.38 b	0.70 a
1L1	0.23 a	0.35 a	0.27 a	0.53 a
2H4	0.42 c	0.50 b	0.45 b	0.81 a
2L18	0.34 b	0.42 ab	0.36 ab	0.60 a

^{1/} The first harvest (age 33 days) was taken on June 17.

^{2/} The second harvest (age 64 days) was taken on July 18.

^{3/} The third harvest (age 94 days) was taken on August 17.

^{4/} The fourth harvest (age 124 days) was taken on September 16.

^{5/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

total plant ratios than 1L1 and 2L18, but at the fourth harvest only 2H4 had the highest ratio and differed significantly with 1H5, 1L1, and 2L18.

There were no significant differences in the fresh and in the dry fibrous roots/leaf blades ratios at the first three harvests, significant differences were obtained at the fourth harvest. At the fourth harvest 2L18 had significantly higher fresh and dry fibrous roots/leaf blades ratios than 1L1 and 2H4.

The fresh and the dry fibrous roots/total plant ratios were significantly different only at the second and the fourth harvests. At the second harvest 2H4 had the lowest fresh fibrous roots/total plant ratio and differed significantly with the other three lines. 1L1 and 2L18 had significantly higher dry fibrous roots/total plant ratios than 2H4. At the fourth harvest 2H4 had significantly lower fresh and dry fibrous roots/total plant ratios than the other three lines.

The fresh crown/leaf blades ratios were significantly different at the third and the fourth harvest, but the dry crown/leaf blades ratios were significantly different only at the fourth harvest. At the third harvest 2H4 had the highest fresh crown/leaf blades ratio. At the fourth harvest 2H4 had the highest and 1L1 the lowest fresh and dry crown/leaf blades ratios.

There were no significant differences in the fresh and in the dry crown/petioles ratios at the third harvest. At the fourth harvest 1H5 and 2H4 had significantly higher fresh crown/petioles ratios than 1L1. Ratios on a dry basis did not differ.

Partition of Assimilates: Table 8 shows the partition of assimilates of four sugar beet lines in the 1975 pot experiment outdoors at each harvest.

At the last three harvests there was a trend for 1H5 and 2H4 to have lower fresh and dry percentages of leaf blades and petioles than 1L1 and 2L18, on the other hand 1H5 and 2H4 showed higher percentages of fresh and dry tap root at each harvest.

The partition of assimilates into fibrous roots was about the same at the first three harvests, however, at the fourth harvest 2H4 had lower percentages of fresh and of dry fibrous roots than 1H5, 1L1, and 2L18.

The partition of assimilates into the crown was about the same between the lines, no clear cut trends were evident from these data.

1976 Growth Chamber Experiment

Percent Emergence: A total of 12 seeds (three seeds per line) were grown on vermiculite in 15 cm pots in a growth chamber on January 12. All seedlings emerged on January 15, each line had 100 percent emergence.

Table 8. Partition of assimilates (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Leaf blades Percent		Petioles Percent		Tap root Percent	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H5	57.81	66.58	13.23	11.19	8.67	10.33
1L1	59.98	61.32	14.45	10.93	5.67	9.00
2H4	59.07	65.62	15.24	13.84	9.33	10.33
2L18	61.66	69.68	12.89	10.64	5.00	6.33
Second Harvest ^{2/}						
1H5	30.66	31.20	17.18	13.43	44.00	48.67
1L1	36.46	37.10	21.63	16.22	32.67	39.00
2H4	26.51	28.44	19.92	13.87	47.33	52.68
2L18	34.48	33.96	23.37	17.12	33.67	41.07
Third Harvest ^{3/}						
1H5	22.29	23.09	15.83	11.25	51.33	53.67
1L1	23.78	26.89	20.58	16.59	45.00	44.33
2H4	17.47	19.93	16.67	12.99	54.00	53.43
2L18	24.23	24.66	20.60	16.78	44.67	46.23
Fourth Harvest ^{4/}						
1H5	19.53	19.71	17.12	12.61	54.00	55.89
1L1	21.62	22.76	19.75	14.59	50.00	52.00
2H4	17.81	18.45	16.23	11.53	57.00	59.00
2L18	20.22	20.26	19.10	14.37	49.67	52.67

^{1/} The first harvest (age 33 days) was taken on June 17.

^{2/} The second harvest (age 64 days) was taken on July 13.

^{3/} The third harvest (age 94 days) was taken on August 17.

^{4/} The fourth harvest (age 124 days) was taken on Sept. 16.

Table 3 (Continued). Partition of assimilates (fresh and dry weight) of four sugar beet lines at East Lansing in 1975 pot experiment outdoors.

Line	Fibrous roots Percent		Crown Percent	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H5	20.29	11.88	--	--
1L1	19.88	15.74	--	--
2H4	16.34	10.19	--	--
2L18	20.45	13.52	--	--
Second Harvest ^{2/}				
1H5	8.16	6.69	--	--
1L1	9.22	7.67	--	--
2H4	6.23	5.02	--	--
2L18	8.48	7.25	--	--
Third Harvest ^{3/}				
1H5	4.21	4.87	6.33	7.12
1L1	4.53	4.89	6.11	7.29
2H4	4.26	4.89	7.60	8.76
2L18	4.43	5.23	6.07	7.00
Fourth Harvest ^{4/}				
1H5	3.25	3.75	6.10	8.03
1L1	3.36	3.07	5.27	7.56
2H4	1.64	1.75	7.32	9.27
2L18	4.29	4.14	6.72	8.56

^{1/} The first harvest (age 33 days) was taken on June 17.

^{2/} The second harvest (age 64 days) was taken on July 18.

^{3/} The third harvest (age 94 days) was taken on August 17.

^{4/} The fourth harvest (age 124 days) was taken on September 16.

Fresh and Dry Matter Production: Table 9 shows the fresh and the dry weights of total plant and of separate plant parts of four sugar beet lines. There were no significant differences in the fresh and in the dry weights of petioles, and of total plant (excludes fibrous roots). 1L1 had significantly lower fresh and dry weights of tap roots than the other three lines. 1H5 and 2L18 had significantly higher fresh weights of leaf blades than 1L1 and 2H4, but had significantly higher dry weights of leaf blades than 1L1 only.

The Ratio of Various Plant Parts: Table 10 shows the ratio of various plant parts of four sugar beet lines.

There were significant differences in the fresh and in the dry tap root/leaf blades ratios. 1H5 and 2H4 had significantly higher fresh and dry tap root/leaf blades ratios than the two low lines.

No significant differences were obtained in the fresh and in the dry petioles/leaf blades ratios between 1H5, 1L1, 2H4, and 2L18.

Significant differences were obtained in the fresh and in the dry tap root/petioles ratios. 1H5 and 2H4 had significantly higher fresh and dry tap root/petioles ratios than 1L1 and 2L18.

As in tap root/petioles ratio, again 1H5 and 2H4 had significantly higher fresh and dry tap root/total plant ratios than 1L1 and 2L18.

Table 9. Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1976 growth chamber experiment.^{1/2/}

Line	Tap root g/plant		Petioles g/plant	
	Fresh	Dry	Fresh	Dry
1H5	30.71 b	4.62 b	42.80 a	3.41 a
1L1	7.20 a	0.72 a	37.97 a	2.11 a
2H4	25.25 b	3.66 b	35.14 a	2.70 a
2L18	18.13 b	2.48 b	53.15 a	3.77 a

Line	Leaf blades g/plant		Total g/plant	
	Fresh	Dry	Fresh	Dry
1H5	76.83 b	9.44 b	150.34 a	17.47 a
1L1	55.61 a	5.44 a	100.78 a	11.37 a
2H4	56.39 a	7.25 ab	116.78 a	13.62 a
2L18	88.78 b	9.97 b	160.30 a	16.22 a

^{1/} Harvest was on February 12, 28 days post emergence.

^{2/} Any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 10. The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1976 growth chamber experiment.^{1/2/}

Line	Tap root/Leaf blades g/g/plant		Petioles/Leaf blades g/g/plant	
	Fresh	Dry	Fresh	Dry
1H5	0.39 b	0.47 b	0.55 a	0.36 a
1L1	0.13 a	0.13 a	0.68 a	0.38 a
2H4	0.45 b	0.43 b	0.64 a	0.38 a
2L18	0.20 a	0.24 a	0.60 a	0.37 a

Line	Tap root/Peti-oles g/g/plant		Tap root/Total plant g/g/plant	
	Fresh	Dry	Fresh	Dry
1H5	0.71 b	1.35 b	0.20 b	0.25 b
1L1	0.19 a	0.33 a	0.07 a	0.08 a
2H4	0.73 b	1.35 b	0.21 b	0.26 b
2L18	0.34 a	0.63 a	0.11 a	0.14 a

^{1/} Harvest was on February 12, 28 days post emergence.

^{2/} Any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Partition of Assimilates: Table 11 shows the partition of assimilates of four sugar beet lines in the growth chamber experiment. 1H5 and 2H4 had lower percentages of fresh and of dry weight of leaf blades and petioles, but higher fresh and dry weight percentages of tap root than 1L1 and 2L18.

Table 11. Partition of assimilates (fresh and dry weight) of four sugar beet lines at East Lansing in 1976 growth chamber experiment

Line	Leaf blades percent		Petioles percent		Tap root percent	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
1H5	51.55	55.81	28.78	19.52	19.67	24.67
1L1	55.28	66.19	37.70	25.48	7.00	8.33
2H4	48.65	53.53	30.02	20.14	21.33	26.33
2L18	55.59	61.97	33.39	23.69	11.00	14.33

1976 Field Experiment

Percent Emergence: In the 1976 field experiment 40 seeds were planted for each line for each replication on May 22. Most seedlings emerged between May 29 and May 31. The results on percent emergence are presented in Table 12.

Table 12. The number of seedlings emerged and the percent of emergence of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment

Hybrid Line	Replication			Total Emerged	Percent Emerged
	1	2	3		
USH20	27	29	31	87	72.5
USH21	32	25	28	85	70.8
2H4	29	26	29	84	70.0
2L18	26	29	28	83	69.2

Table 12 shows that USH20 had the highest, and 2L18 the lowest percentage emergence.

Fresh and Dry Matter Production: Table 13 shows the fresh and the dry weights of total plant and of separate plant parts of two hybrids and two lines of sugar beet at each harvest in the 1976 field experiment.

There were no significant differences in the fresh and in the dry weights of total plant (excludes fibrous roots) at the first harvest. At the second harvest USH20 and USH21 had significantly higher fresh and dry weights of total plant than 2H4. At the third harvest USH20 and USH21 were significantly different than 2H4 and 2L18 in the fresh and in the dry weights of total plant (Table 13 and Figure 7).

The fresh weights of leaf blades were significantly different at each harvest, but the dry weights of leaf blades were significantly different only at the third

Table 13. Fresh and dry matter production of total and various plant parts of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.

Hybrid Line	Total g/plant		Leaf blades g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
USH20	88.04 a ^{4/}	8.46 a ^{4/}	55.56 b ^{4/}	5.41 a ^{4/}
USH21	65.09 a	6.53 a	42.33 ab	4.37 a
2H4	44.86 a	4.78 a	28.11 a	3.10 a
2L18	67.88 a	7.05 a	43.91 ab	4.76 a
Second Harvest ^{2/}				
USH20	633.40 b	75.50 b	217.83 bc	26.29 a
USH21	648.59 b	76.86 b	244.57 c	28.74 a
2H4	382.64 a	49.34 a	128.31 a	18.12 a
2L18	477.34 ab	58.48 ab	178.29 ab	23.63 a
Third Harvest ^{3/}				
USH20	1734.28 b	253.01 b	431.38 c	64.07 b
USH21	1547.40 b	228.84 b	441.64 c	66.60 b
2H4	1136.88 a	156.23 a	283.64 a	38.27 a
2L18	1229.78 a	165.52 a	353.28 b	46.95 a

1/ The first harvest (age 34 days) was taken on July 3.

2/ The second harvest (age 62 days) was taken on August 1.

3/ The third harvest (age 102 days) was taken on Sept. 10.

4/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 13 (Continued). Fresh and dry matter production of total and various plant parts of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.

Hybrid Line	Tap root g/plant		Petioles g/plant		Crown g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
USH20	11.56 a ^{4/}	1.35 a ^{4/}	20.92 a ^{4/}	1.70 a ^{4/}	--	--
USH21	8.66 a	0.95 a	14.70 a	1.22 a	--	--
2H4	6.91 a	0.81 a	9.85 a	0.88 a	--	--
2L18	8.68 a	1.04 a	15.29 a	1.25 a	--	--
Second Harvest ^{2/}						
USH20	196.11 a	28.27 a	188.09 b	16.53 b	31.37 a	4.40 a
USH21	218.79 a	28.15 a	190.00 b	15.66 b	31.20 a	4.30 a
2H4	145.51 a	20.72 a	89.08 a	7.65 a	19.74 a	2.85 a
2L18	151.18 a	21.21 a	123.39 a	10.18 a	24.49 a	3.46 a
Third Harvest ^{3/}						
USH20	852.98 c	130.07 b	328.40 c	38.03 c	121.52 b	20.83 b
USH21	718.85 bc	114.40 b	278.62 bc	31.49 bc	108.62 b	19.36 b
2H4	584.16 ab	80.56 a	180.98 a	21.40 a	90.10 a	16.33 a
2L18	538.54 a	75.18 a	251.21 b	28.56 ab	86.73 a	14.82 a

^{1/} The first harvest (age 34 days) was taken on July 3.

^{2/} The second harvest (age 62 days) was taken on August 1.

^{3/} The third harvest (age 102 days) was taken on Sept. 10.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

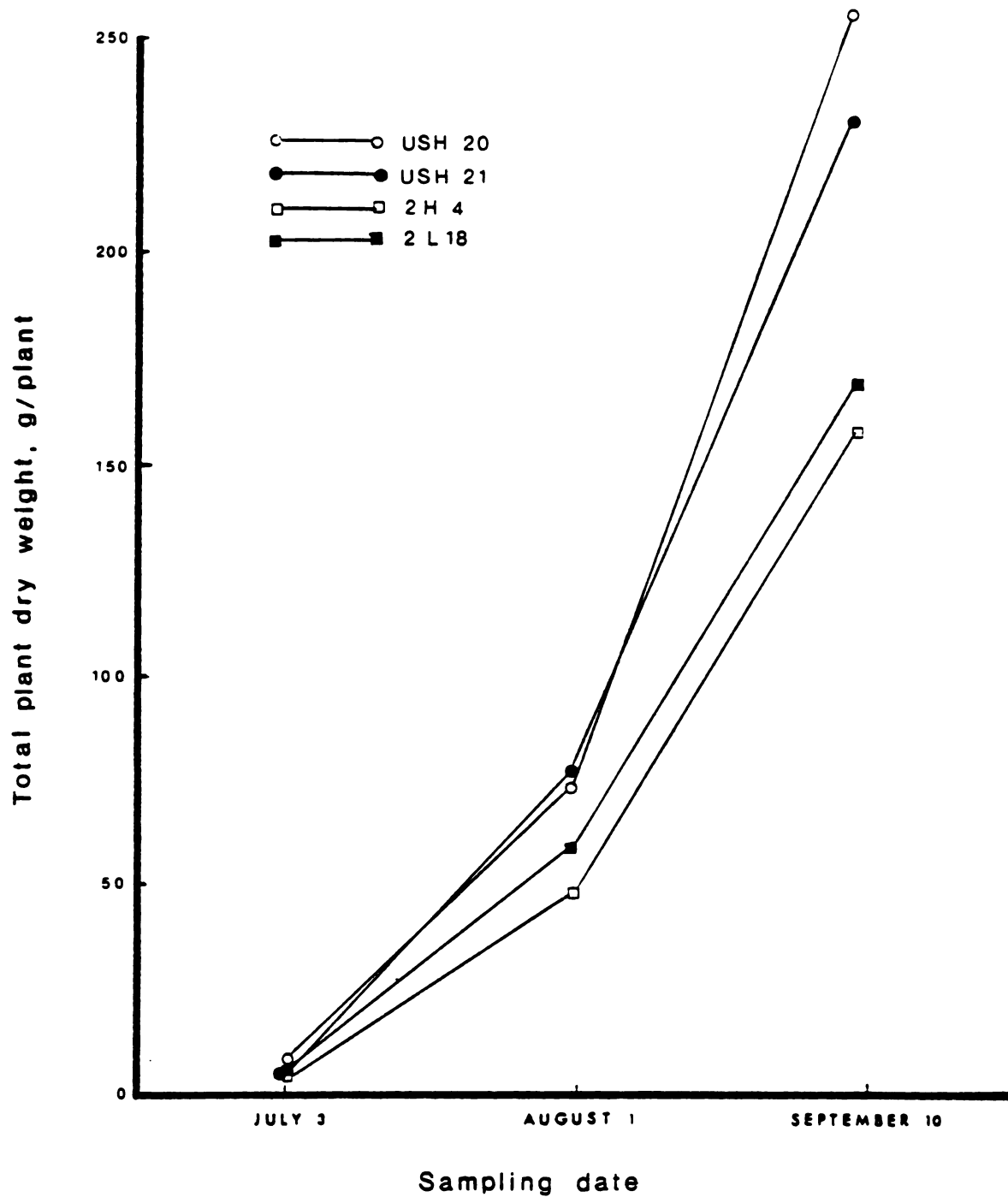


Figure 7. Changes in dry weight of total plant of two hybrids and two lines of sugar beet during the growing season at East Lansing in 1976 field experiment.

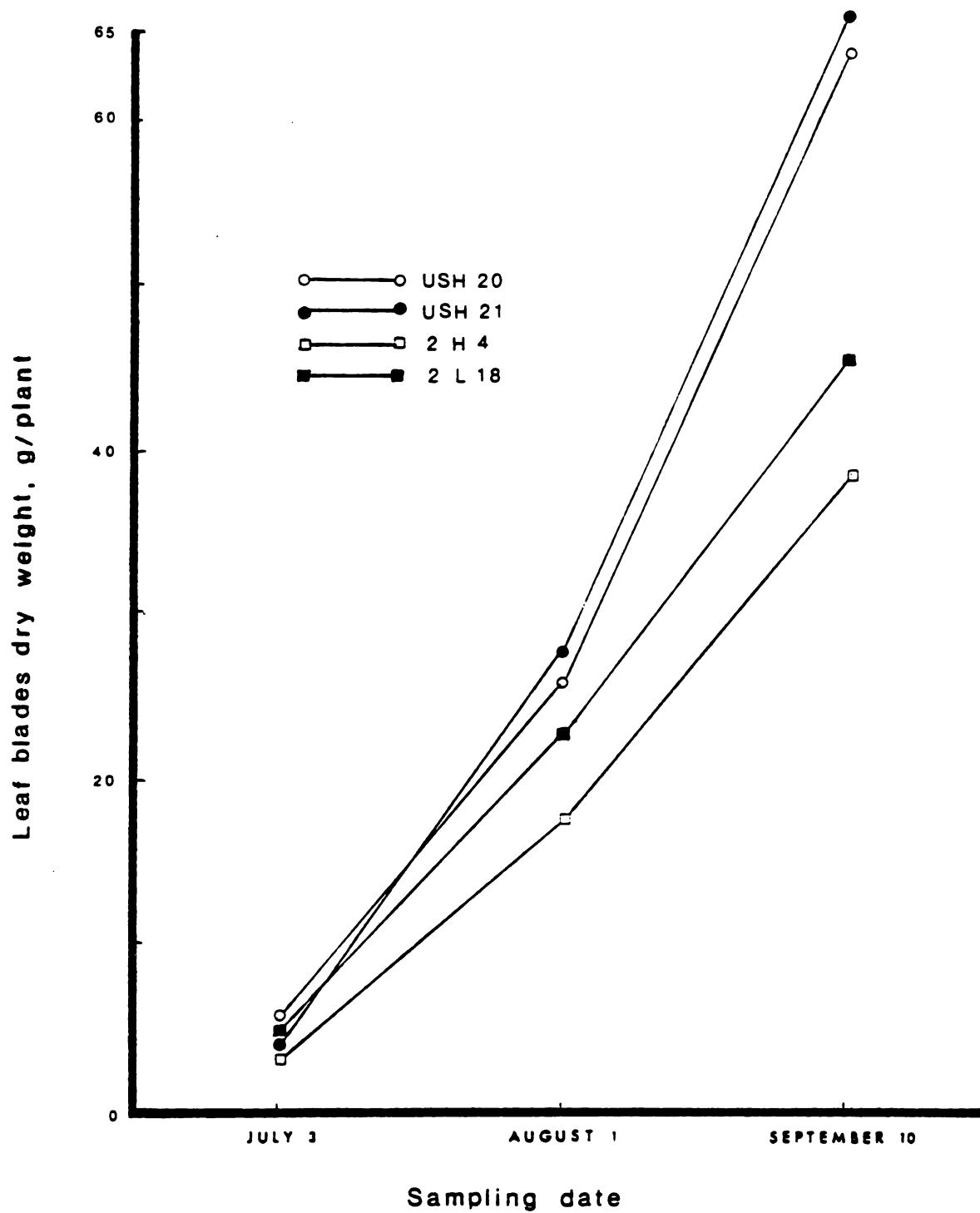


Figure 8. Changes in dry weight of leaf blades of two hybrids and two lines of sugar beet during the growing season at East Lansing in 1976 field experiment.

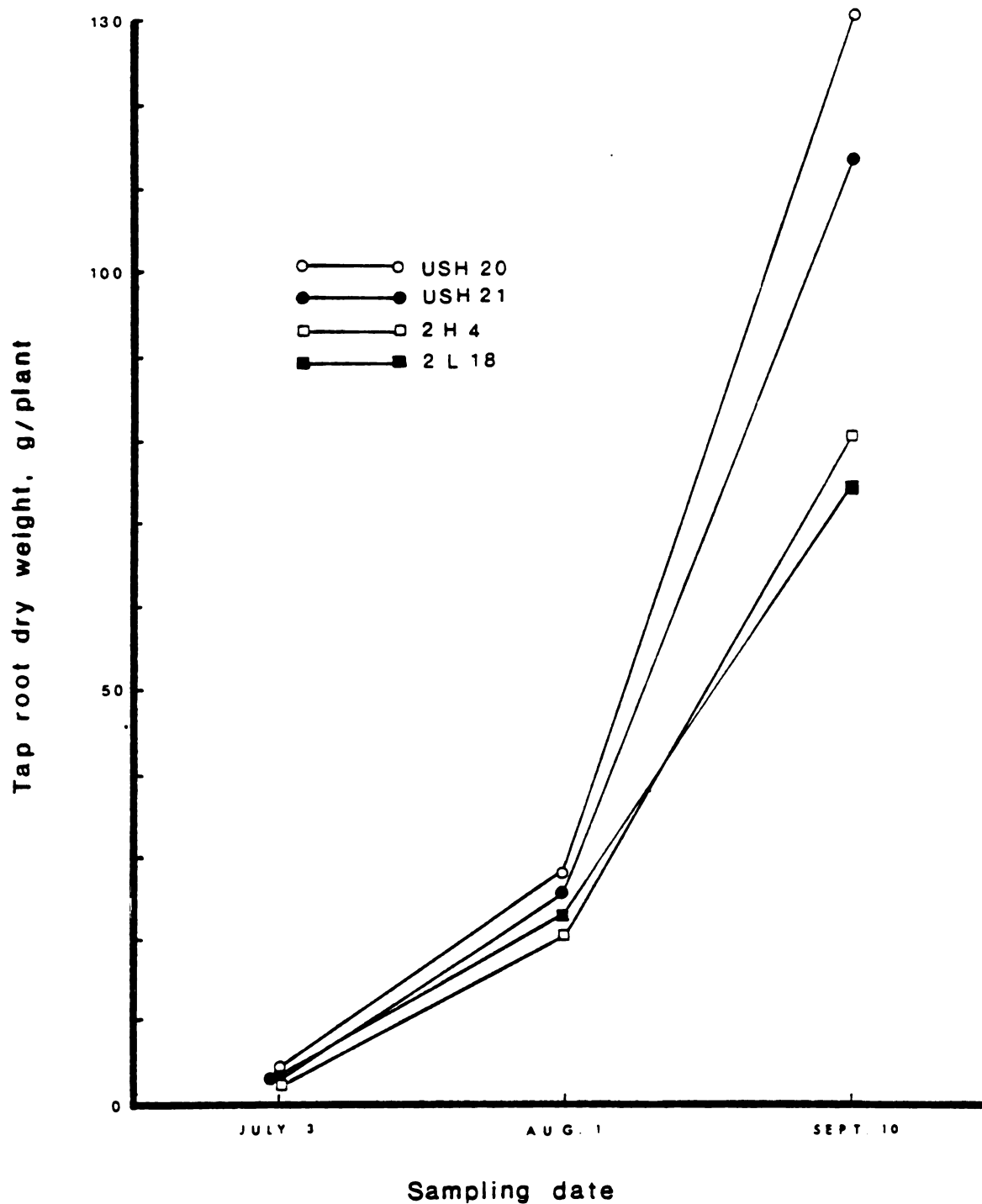


Figure 9. Changes in dry weight of tap root of two hybrids and two lines of sugar beet during the growing season at East Lansing in 1976 field experiment.

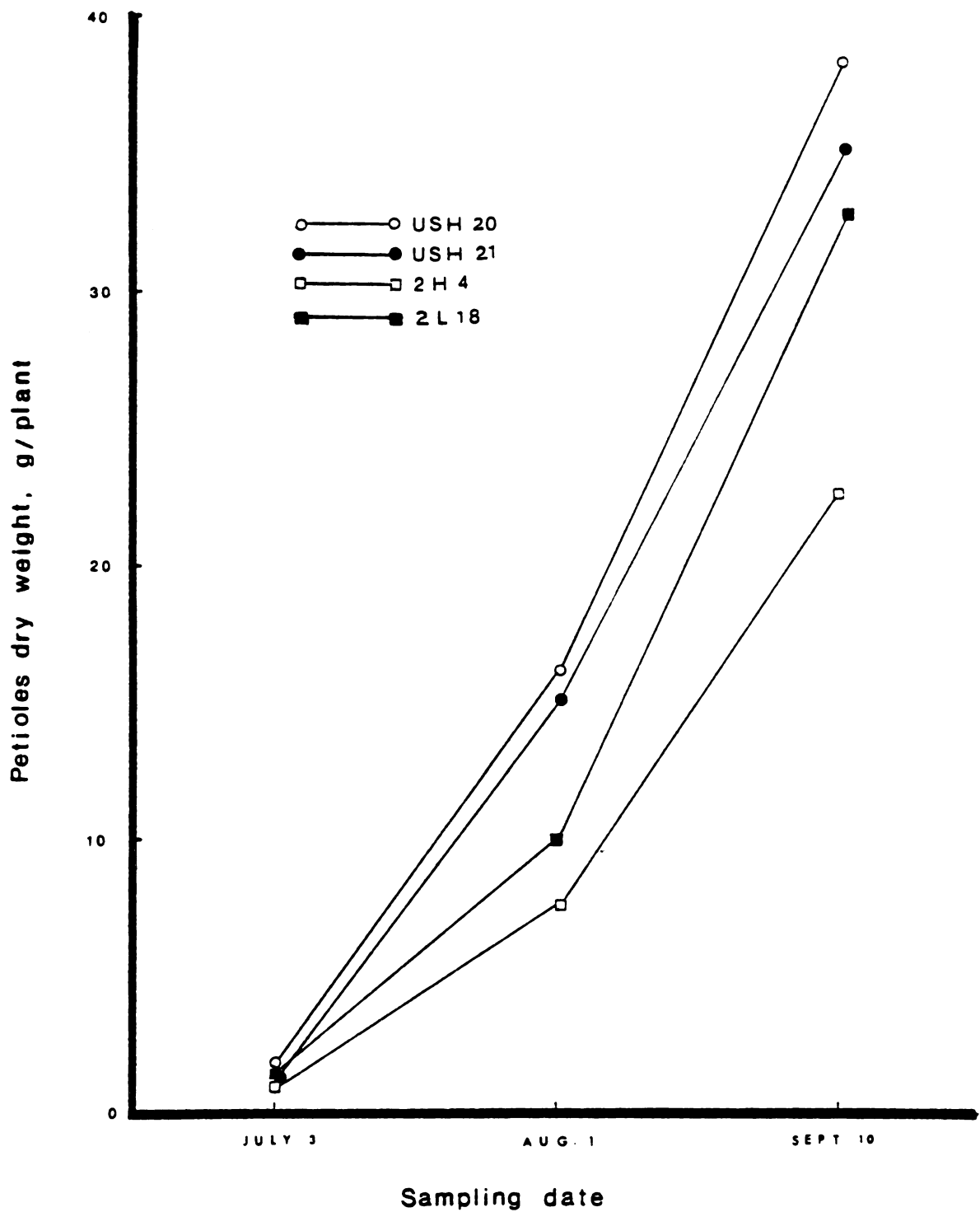


Figure 10. Changes in dry weight of petioles of two hybrids and two lines of sugar beet during the growing season at East Lansing in 1976 field experiment.

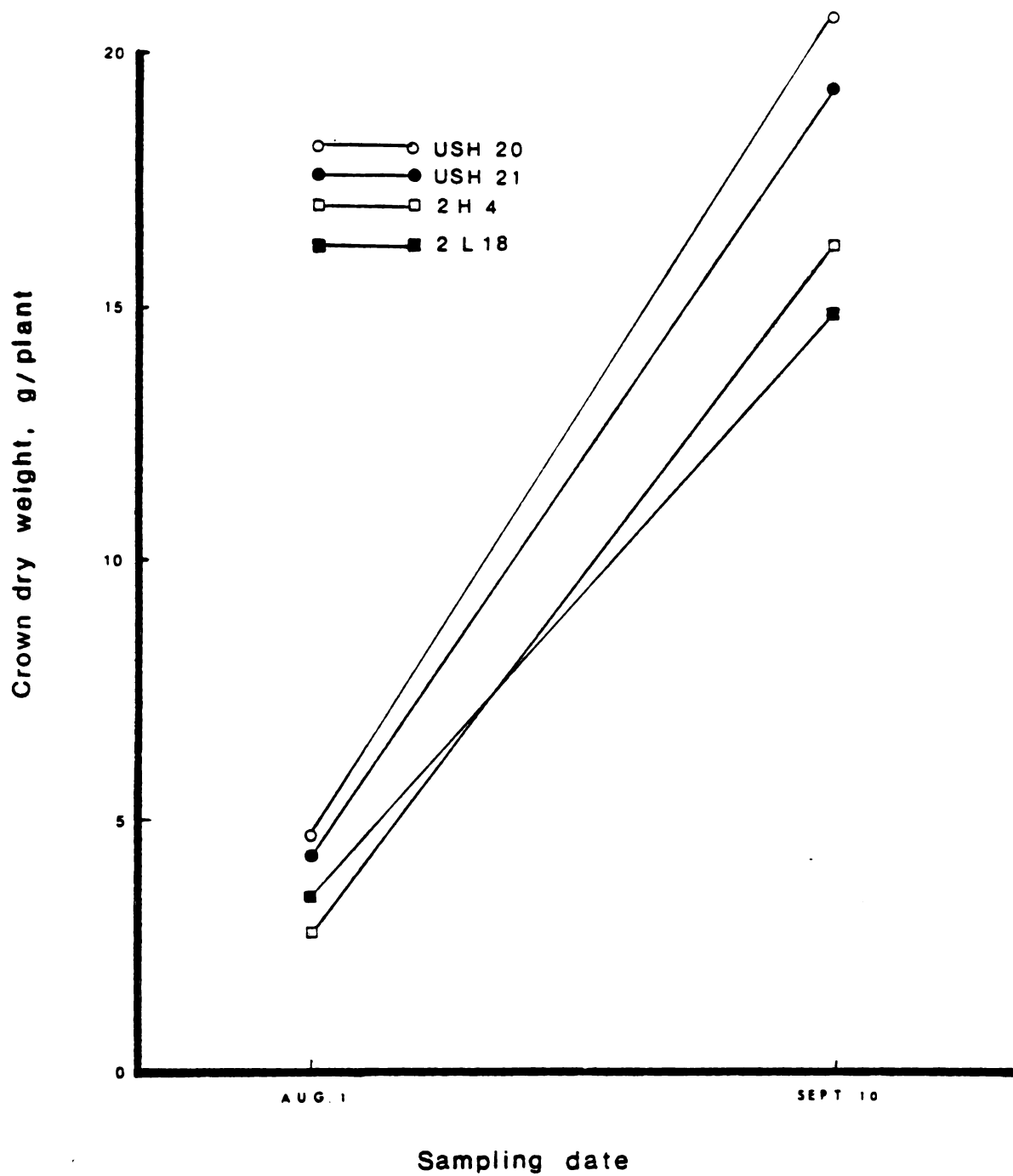


Figure 11. Changes in dry weight of crown of two hybrids and two lines of sugar beet during the growing season at East Lansing in 1976 field experiment.

harvest. At the first harvest USH20 had the highest and 2H4 the lowest fresh weight of leaf blades. At the second harvest USH21 had the highest; 2H4 and 2L18 the lowest fresh weights of leaf blades. At the third harvest USH20 and USH21 had significantly higher fresh and dry weights of leaf blades than 2H4 and 2L18 (Table 13 and Figure 8).

The fresh and the dry weights of tap root were significantly different only at the third harvest. USH20 had significantly higher fresh weight of tap root than 2H4 and 2L18; USH20 and USH21 had significantly greater dry weights of tap root than 2H4 and 2L18 (Table 13 and Figure 9).

No significant differences were obtained in the fresh and in the dry weights of petioles at the first harvest. At the second harvest USH20 and USH21 had significantly higher fresh and dry weights of petioles than 2H4 and 2L18. At the third harvest USH20 had the highest, 2H4 and 2L18 the lowest fresh and dry weights of petioles (Table 13 and Figure 10).

The fresh and the dry weights of crown were significantly different only at the third harvest. USH20 and USH21 had significantly higher fresh and dry weights of crown than 2H4 and 2L18 (Table 13 and Figure 11).

The Ratio of Various Plant Parts: Table 14 shows the ratios of various plant parts of two hybrids and two lines of sugar beet at each harvest in 1976 field experiment.

The fresh tap root/leaf blades ratios were significantly different at the first and the third harvest, while the dry tap root/leaf blades ratios were significantly different only at the third harvest. At the first harvest 2H4 differed significantly from USH20, USH21, and 2L18 in the fresh tap root/leaf blades ratio. At the third harvest USH 20 and 2H4 had significantly higher fresh and dry tap root/leaf blades ratios than USH 21 and 2L18.

There were no significant differences in the fresh and in the dry petioles/leaf blades ratios between USH20, USH21, 2H4, and 2L18 at any harvest.

The fresh tap root/petioles ratios were significantly different at the second and the third harvest, but the dry tap root/petioles ratios were significantly different only at the second harvest. At the second harvest 2H4 had significantly higher fresh and dry tap root/petioles ratios than USH20, USH21, and 2L18. At the third harvest 2H4 had the highest, USH 21 and 2L18 the lowest fresh tap root/petioles ratios.

At the first harvest 2H4 had a significantly higher fresh tap root/total plant ratio than USH20, USH21 and 2L18. There were no significant differences in the fresh and in the dry tap root/total plant ratios at the second harvest. At the third harvest USH20 and 2H4 had significantly higher fresh and dry tap root/total plant ratios than 2L18.

Table 14. The ratio of various plant parts (fresh and dry weight) of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.

Hybrid Line	Tap root/Leaf blades g/g/plant		Petioles/Leaf blades g/g/plant		Tap root/Peti- oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
USH20	0.21 a ^{4/}	0.25 a ^{4/}	0.36 a ^{4/}	0.31 a ^{4/}	0.59 a ^{4/}	0.86 a ^{4/}
USH21	0.20 a	0.22 a	0.34 a	0.27 a	0.59 a	0.81 a
2H4	0.25 b	0.27 a	0.36 a	0.29 a	0.71 a	0.96 a
2L18	0.20 a	0.22 a	0.35 a	0.27 a	0.57 a	0.82 a
Second Harvest ^{2/}						
USH20	0.90 a	1.07 a	0.81 a	0.64 a	1.07 a	1.73 a
USH21	0.89 a	0.97 a	0.83 a	0.56 a	1.10 a	1.74 a
2H4	1.17 a	1.23 a	0.68 a	0.42 a	1.74 b	2.96 b
2L18	0.88 a	0.92 a	0.67 a	0.43 a	1.33 a	2.26 a
Third Harvest ^{3/}						
USH20	2.01 b	2.05 b	0.75 a	0.58 a	2.77 ab	3.70 a
USH21	1.64 a	1.69 a	0.63 a	0.48 a	2.65 a	3.68 a
2H4	2.18 b	2.22 b	0.65 a	0.51 a	3.38 b	4.19 a
2L18	1.60 a	1.67 a	0.75 a	0.60 a	2.36 a	3.07 a

^{1/} The first harvest (age 34 days) was taken on July 3.

^{2/} The second harvest (age 62 days) was taken on August 1.

^{3/} The third harvest (age 102 days) was taken on Sept. 10.

^{4/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 14 (Continued). The ratio of various plant parts (fresh and dry weight) of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.

Hybrid Line	Tap root/Total plant g/g/plant		Crown/Leaf blades g/g/plant		Crown/Peti- oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
USH20	0.13 a ^{4/}	0.16 a ^{4/}	--	--	--	--
USH21	0.13 a	0.14 a	--	--	--	--
2H4	0.15 b	0.17 a	--	--	--	--
2L18	0.13 a	0.15 a	--	--	--	--
Second Harvest ^{2/}						
USH20	0.31 a	0.37 a	0.14 a	0.16 a	0.17 a	0.26 a
USH21	0.32 a	0.36 a	0.13 a	0.15 a	0.16 a	0.26 a
2H4	0.37 a	0.42 a	0.16 a	0.16 a	0.22 b	0.36 a
2L18	0.32 a	0.36 a	0.14 a	0.14 a	0.20 ab	0.35 a
Third Harvest ^{3/}						
USH20	0.49 bc	0.51 b	0.29 b	0.33 b	0.40 a	0.59 a
USH21	0.46 ab	0.49 ab	0.24 a	0.29 a	0.40 a	0.62 a
2H4	0.51 c	0.51 b	0.34 c	0.44 c	0.52 b	0.80 b
2L18	0.44 a	0.45 a	0.26 ab	0.32 ab	0.38 a	0.58 a

1/ The first harvest (age 34 days) was taken on July 3.

2/ The second harvest (age 62 days) was taken on August 1.

3/ The third harvest (age 102 days) was taken on Sept. 10.

4/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

No significant differences were obtained in the fresh and in the dry crown/leaf blades ratios at the second harvest. At the third harvest significant differences were obtained in the fresh and in the dry crown/leaf blades ratios. 2H4 had the highest and USH21 the lowest fresh and dry crown/leaf blades ratios.

The fresh crown/petioles ratios were significantly different at the second and the third harvest, but the dry crown/petioles ratios were significantly different only at the third harvest. At the second harvest 2H4 had the highest, USH20 and USH21 the lowest fresh crown/petioles ratios. At the third harvest 2H4 had significantly higher fresh and dry crown/petioles ratios than USH20, USH21, and 2L18.

Partition of Assimilates: Table 15 shows the partition of assimilates of two hybrids and two lines of sugar beet at each harvest in the 1976 field experiment.

The partition of assimilates into leaf blades and petioles was about the same between USH20, USH21, 2H4, and 2L18 at each harvest.

2H4 showed higher fresh and dry weight percentages of tap root than USH20, USH21, and 2L18 at each harvest.

At the third harvest 2H4 had a higher dry weight percentage of crown than USH20, USH21, and 2L18.

Sugar Analysis: Table 16 shows the result of sugar analysis of two hybrids and two lines of sugar beet in East Lansing in the 1976 field experiment.

Table 15. Partition of assimilates (fresh and dry weight) of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.

Hybrid Line	Leaf blades Percent		Petioles Percent		Tap root Percent		Crown Percent	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}								
USH20	63.11	63.98	23.76	20.29	13.12	15.69	--	--
USH21	64.04	66.92	23.28	18.68	12.66	14.39	--	--
2H4	62.66	64.80	21.96	18.19	15.37	17.00	--	--
2L18	64.69	67.58	22.53	17.73	12.76	14.67	--	--
Second Harvest ^{2/}								
USH20	34.68	34.92	29.69	21.93	30.66	37.40	4.95	5.73
USH21	35.01	38.10	29.09	20.47	31.66	36.00	4.23	5.42
2H4	33.78	36.73	23.39	15.40	37.66	42.08	5.16	5.78
2L18	37.35	40.41	25.85	17.51	31.66	36.33	5.13	5.84
Third Harvest ^{3/}								
USH20	24.89	25.32	18.99	15.03	49.00	51.37	7.11	8.27
USH21	28.05	28.84	18.01	13.83	46.00	48.66	7.93	8.66
2H4	24.85	24.64	15.89	13.90	51.33	52.00	7.92	10.45
2L18	27.83	28.36	20.83	17.32	43.66	45.33	7.68	8.99

^{1/} The first harvest (age 34 days) was taken on July 3.

^{2/} The second harvest (age 62 days) was taken on August 1.

^{3/} The third harvest (age 102 days) was taken on Sept. 10.

Table 16. Percent sucrose, percent clear juice purity, and recoverable white sugar per ton in roots of two hybrids and two lines of sugar beet at East Lansing in 1976 field experiment.^{1/2/}

Hybrid Line	Sucrose Percent	C.J. Purity Percent	R.W.S./Ton
USH20	13.91 a	93.37 a	231.65 a
USH21	14.84 a	93.53 a	248.83 a
2H4	15.05 a	93.37 a	251.57 a
2L18	14.60 a	92.89 a	241.55 a

^{1/} Plant samples for sugar analysis were taken on September 10 (age 102 days).

^{2/} Any two means in the same column followed by the same letter do not differ significantly at the 5 percent level probability according to Duncan's new multiple-range test.

There were no significant differences in percent sucrose, percent clear juice purity, and recoverable white sugar per ton, between USH20, USH21, 2H4, and 2L18.

1977 Field Experiment

Percent Emergence: In the 1977 field experiment 50 seeds were planted for each line for each replication on May 18. Most seedlings emerged between May 24 and May 27. The result of percentage emergence is presented in Table 17. The percent emergence for each line was about about the same.

Table 17. The number of seedlings emerged and the percent of emergence of four sugar beet lines at East Lansing in 1977 field experiment

Line	Replication					Total Emerged	Percent Emerged
	1	2	3	4	5		
1H1	30	36	32	41	39	178	71.2
1L6	29	38	42	37	40	186	74.4
2H2	29	32	37	41	38	177	80.9
2L6	31	34	41	38	36	180	72.0

Fresh and Dry Matter Production: Table 18 shows the fresh and the dry weight of total plant and of separate plant parts of four sugar beet lines at each harvest in 1977 field experiment.

The dry and the fresh weights of total plant (excludes fibrous roots) did not differ significantly at each harvest,

but at the last two harvests 1H1 and 2H2 showed somewhat higher fresh and dry weight of total plant than 1L6 and 2L6 (Table 18 and Figure 12).

No significant differences were obtained in the dry weights of leaf blades at any harvest; the fresh weights of leaf blades were significantly different only at the second harvest. At the second harvest 1L6 and 2L6 had significantly higher fresh weights of leaf blades than 1H1 and 2H2. At the fifth harvest 2H2 showed higher fresh and dry weights of leaf blades than 1H1, 1L6, and 2L6 (Figure 13).

There were no significant differences in the fresh and in the dry weights of tap root at any harvest. However, there was a trend at the second, the fourth, and the fifth harvests for 1H1 and 2H2 to have higher fresh and dry weights of tap root than 1L6 and 2L6 (Table 18 and Figure 14).

There were no significant differences in the fresh weights of petioles at any harvest. Dry weights of petioles were significantly different only at the first harvest. 1L6 and 2H2 had significantly higher dry weights of petioles than 2L6. Figure 15 shows that at the second and the third harvest the dry weights of petioles of 1L6 and 2H2 increased, at the fourth harvest both dry weights decreased, at the fifth harvest the dry weight of petioles of 2H2 increased again.

Table 18. Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1977 field experiment.

Line	Total g/plant		Leaf blades g/plant	
	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}				
1H1	14.84 a ^{6/}	1.58 a ^{6/}	10.76 a ^{6/}	1.20 a ^{6/}
1L6	16.05 a	1.78 a	11.80 a	1.37 a
2H2	16.39 a	1.77 a	11.54 a	1.31 a
2L6	17.28 a	1.75 a	12.93 a	1.37 a
Second Harvest ^{2/}				
1H1	291.73 a	39.63 a	122.52 a	16.82 a
1L6	347.70 a	44.09 a	169.88 b	21.68 a
2H2	317.59 a	42.58 a	127.50 a	16.35 a
2L6	330.63 a	36.95 a	174.13 b	17.72 a
Third Harvest ^{3/}				
1H1	632.81 a	78.77 a	166.95 a	22.16 a
1L6	775.01 a	94.61 a	227.43 a	28.85 a
2H2	707.83 a	86.53 a	202.12 a	26.08 a
2L6	614.39 a	77.56 a	211.50 a	28.34 a
Fourth Harvest ^{4/}				
1H1	1338.59 a	173.54 a	229.34 a	26.45 a
1L6	1210.16 a	157.71 a	254.78 a	30.69 a
2H2	1337.48 a	175.37 a	220.69 a	27.65 a
2L6	1196.81 a	157.21 a	252.75 a	31.15 a
Fifth Harvest ^{5/}				
1H1	1821.21 a	215.89 a	227.66 a	28.06 a
1L6	1604.44 a	192.37 a	230.59 a	29.05 a
2H2	1999.64 a	242.71 a	257.91 a	33.96 a
2L6	1580.10 a	193.45 a	225.84 a	28.32 a

- 1/ The first harvest (age 25 days) was taken on June 20.
2/ The second harvest (age 47 days) was taken on July 12.
3/ The third harvest (age 68 days) was taken on August 2.
4/ The fourth harvest (age 89 days) was taken on August 23.
5/ The fifth harvest (age 109 days) was taken on Sept. 12.
6/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 18 (Continued). Fresh and dry matter production of total and various plant parts of four sugar beet lines at East Lansing in 1977 field experiment.

Line	Tap root g/plant		Petioles g/plant		Crown g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H1	1.25 a ^{6/}	0.13 a ^{6/}	2.82 a ^{6/}	0.25 ab ^{6/}	--	--
1L6	1.30 a	0.14 a	2.95 a	0.26 b	--	--
2H2	1.77 a	0.19 a	3.09 a	0.27 b	--	--
2L6	1.38 a	0.15 a	2.97 a	0.23 a	--	--
Second Harvest ^{2/}						
1H1	73.59 a	10.96 a	95.62 a	11.85 a	--	--
1L6	56.06 a	8.50 a	121.76 a	13.76 a	--	--
2H2	81.93 a	12.62 a	108.16 a	13.61 a	--	--
2L6	48.90 a	6.78 a	107.55 a	12.35 a	--	--
Third Harvest ^{3/}						
1H1	278.15 a	35.94 a	156.45 a	14.80 a	31.26 a	4.26 a
1L6	294.25 a	40.15 a	218.20 a	20.82 a	35.13 a	4.78 a
2H2	285.78 a	39.23 a	184.07 a	16.37 a	35.85 a	4.89 a
2L6	227.02 a	30.66 a	153.57 a	15.41 a	22.31 a	3.15 a
Fourth Harvest ^{4/}						
1H1	781.07 a	105.45 a	190.25 a	16.76 a	137.93 a	24.88 a
1L6	622.61 a	88.85 a	227.67 a	19.35 a	105.14 a	18.82 a
2H2	825.79 a	112.17 a	171.34 a	14.34 a	119.66 a	21.22 a
2L6	631.73 a	88.62 a	209.57 a	18.50 a	102.76 a	18.94 a
Fifth Harvest ^{5/}						
1H1	1107.69 a	125.72 a	210.16 a	18.47 a	275.69 a	43.62 a
1L6	964.88 a	112.35 a	206.61 a	18.68 a	202.35 a	32.65 a
2H2	1256.10 a	151.11 a	243.92 a	22.21 a	241.71 a	35.82 a
2L6	949.74 a	114.47 a	190.04 a	17.48 a	214.48 a	33.18 a

- 1/ The first harvest (age 25 days) was taken on June 20.
2/ The second harvest (age 47 days) was taken on July 12.
3/ The third harvest (age 68 days) was taken on August 2.
4/ The fourth harvest (age 89 days) was taken on August 23.
5/ The fifth harvest (age 109 days) was taken on Sept. 12.
6/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

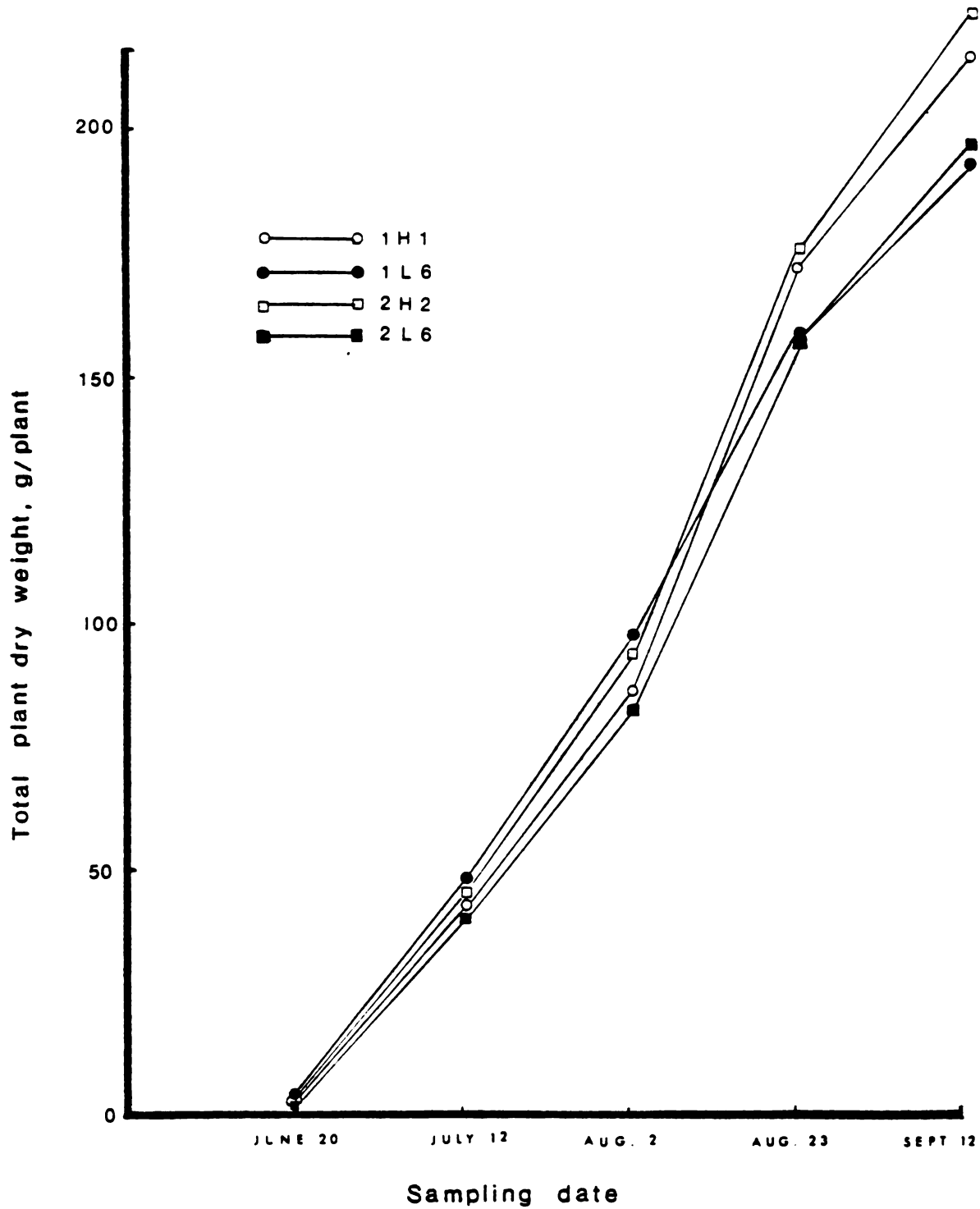


Figure 12. Changes in dry weight of total plant of four sugar beet lines during the growing season at East Lansing in 1977 field experiment.

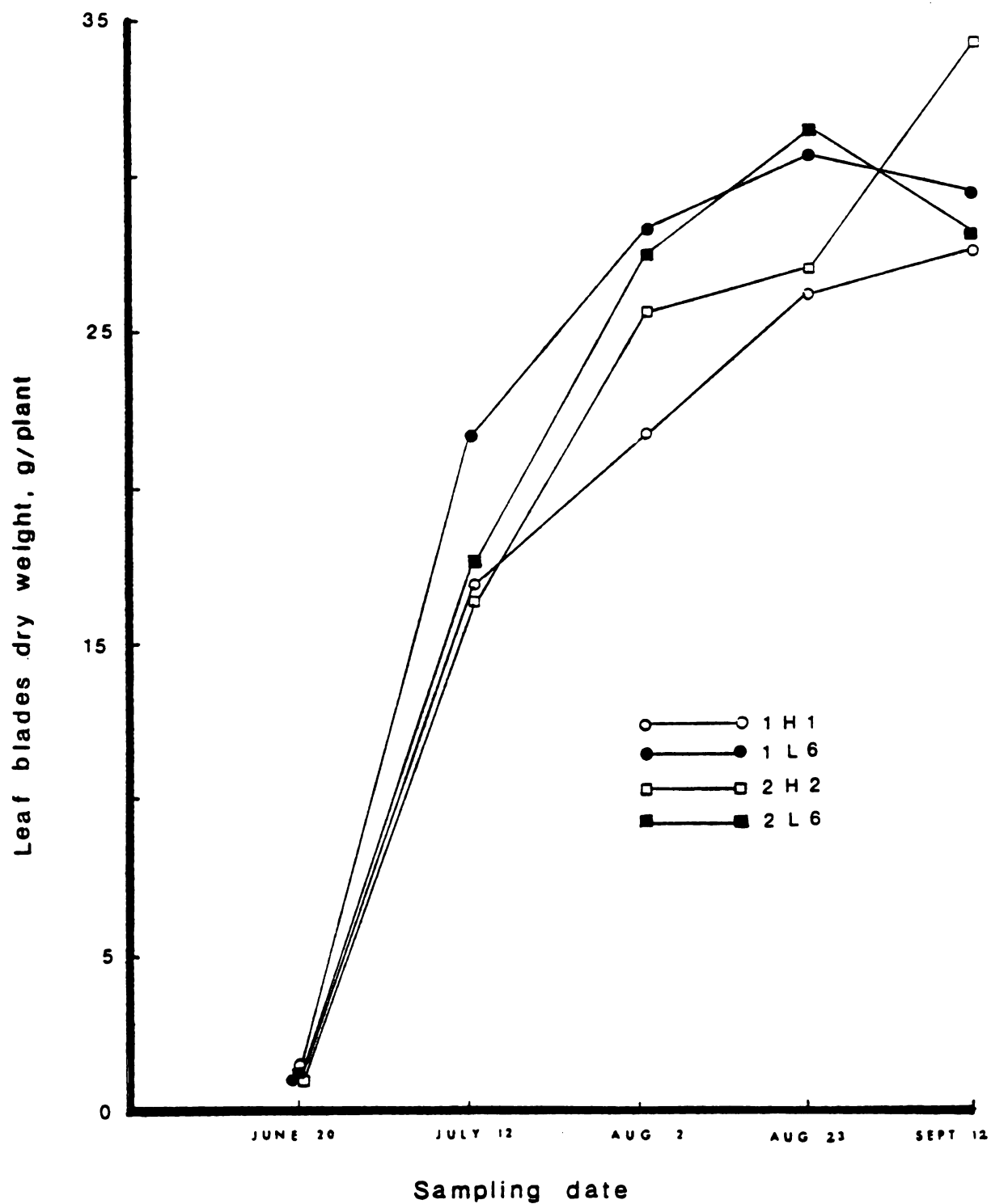


Figure 13. Changes in dry weight of leaf blades of four sugar beet lines during the growing season at East Lansing in 1977 field experiment.

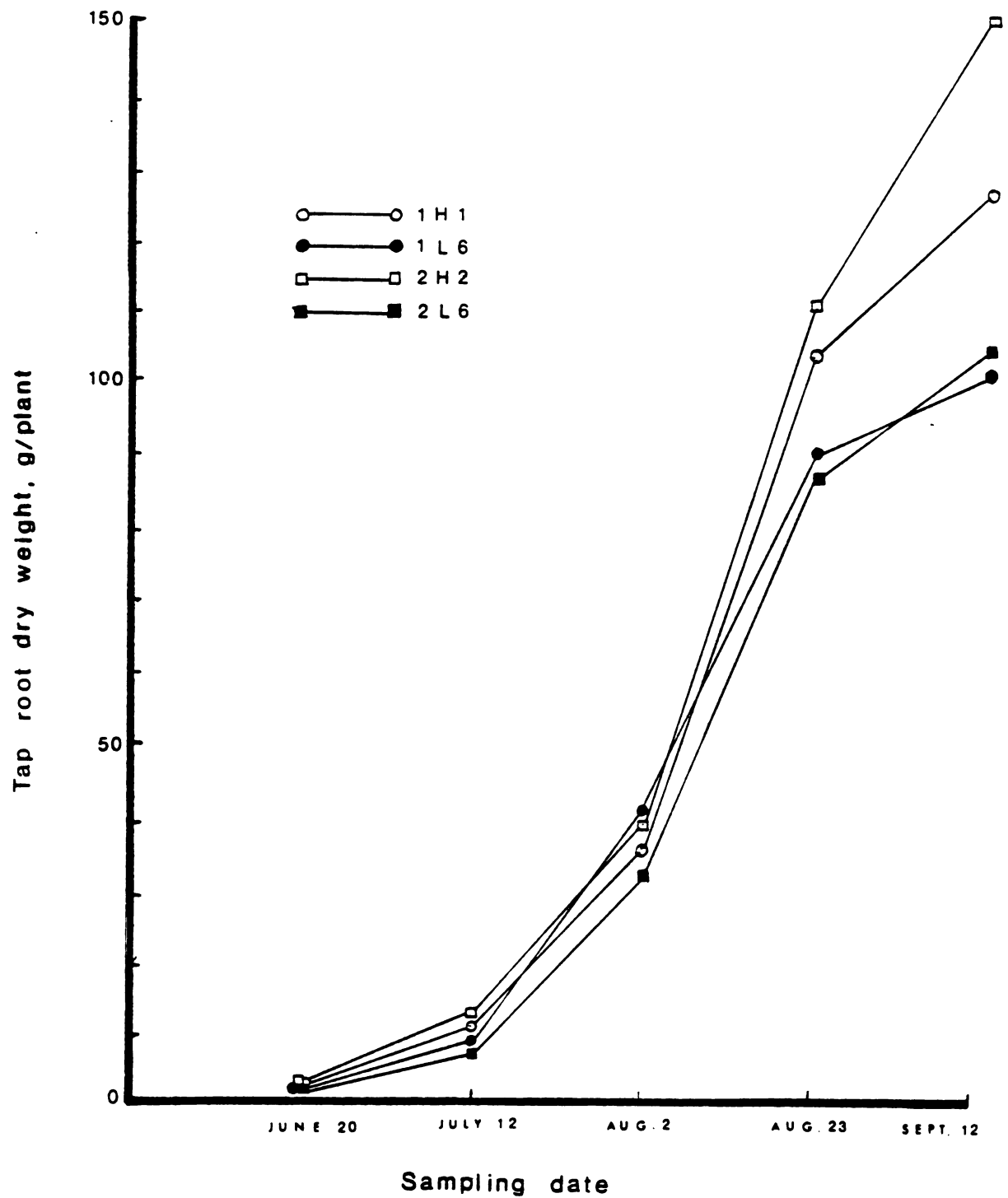


Figure 14. Changes in dry weight of tap root of four sugar beet lines during the growing season at East Lansing in 1977 field experiment.

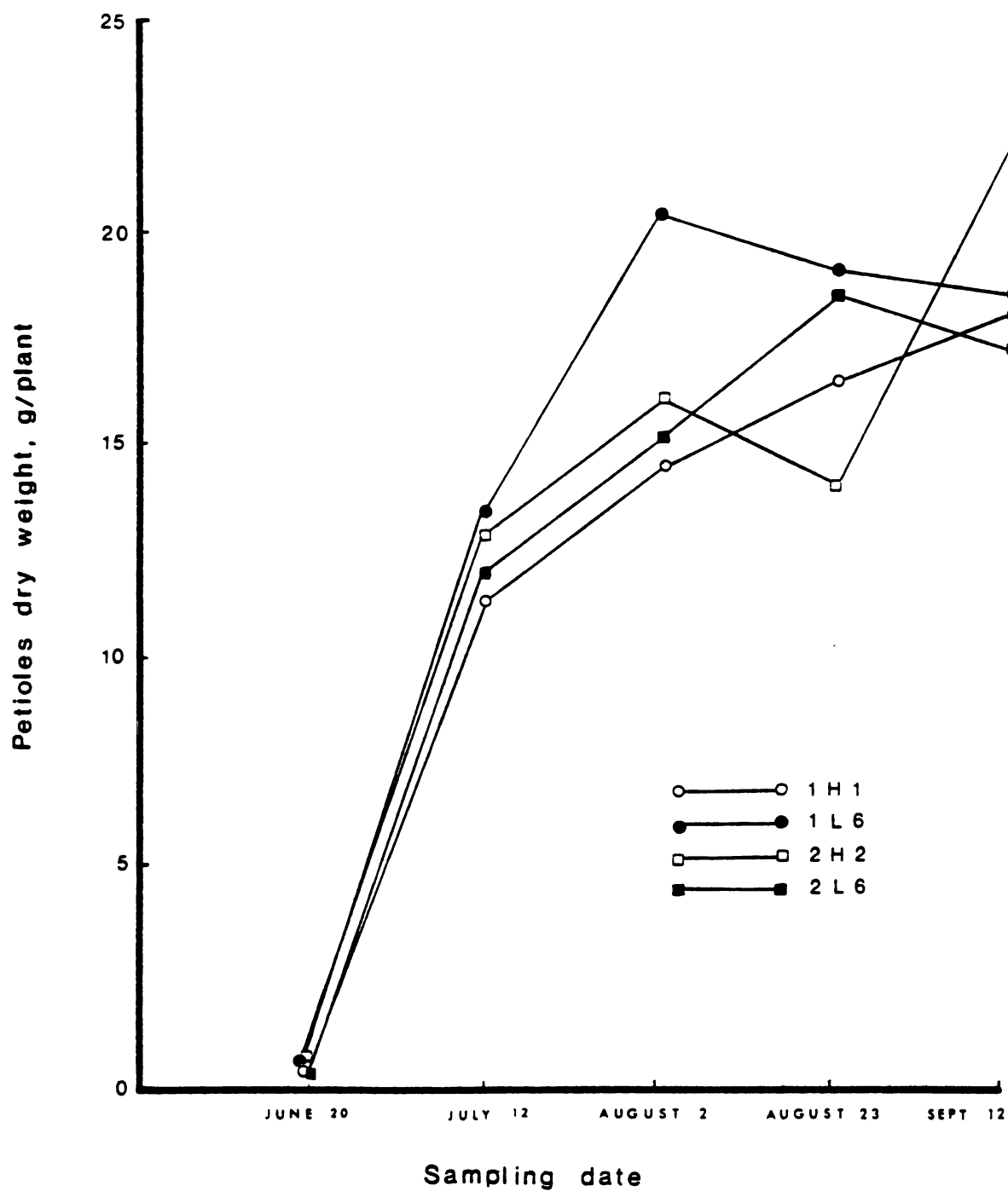


Figure 15. Changes in dry weight of petioles of four sugar beet lines during the growing season at East Lansing in 1977 field experiment.

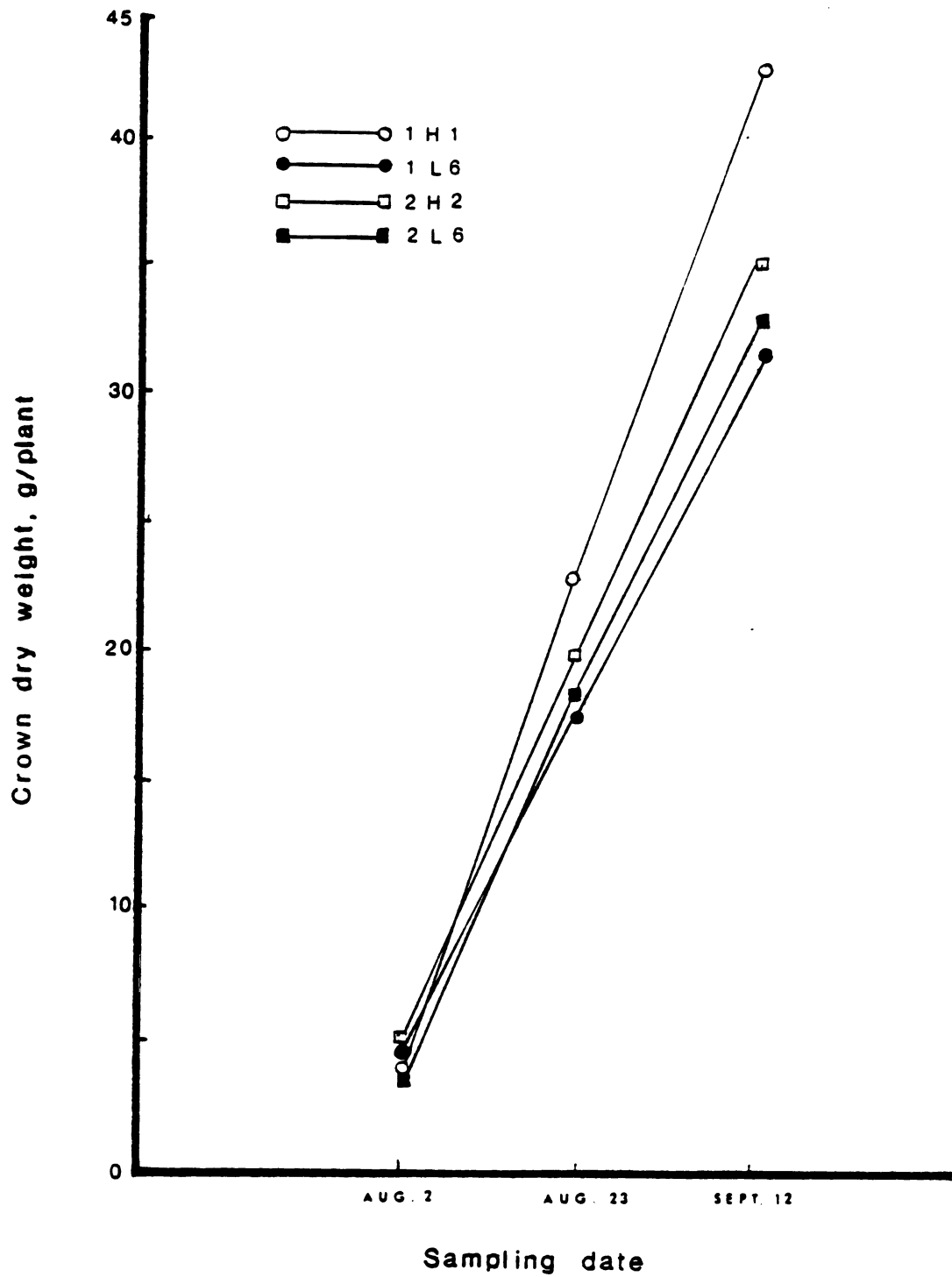


Figure 16. Changes in dry weight of crown of four sugar beet lines during the growing season at East Lansing in 1977 field experiment.

The fresh and the dry weights of crown did not differ significantly at any harvest, however, there was a trend at the fourth and the fifth harvest for 1H1 and 2H2 to have higher fresh and dry weights of crown than 1L1 and 2L6.

The Ratio of Various Plant Parts: Table 19 shows the ratio of various plant parts of four sugar beet lines at each harvest in 1977 field experiment.

There were no significant differences in the dry tap root/leaf blades ratios at any harvest, but the fresh tap root/leaf blades ratios were significantly different at the first and the second harvest. At the first harvest 2H2 had a significantly higher fresh tap root/leaf blades ratio than 1L6 and 2L6. At the second harvest 1H1 and 2H2 had the highest, and 1L6 and 2L6 the lowest ratios.

The fresh petioles/leaf blades ratios were significantly different only at the second harvest. 2H2 had the highest and 2L6 the lowest fresh petioles/leaf blades ratios.

The fresh and the dry tap root/petioles ratios were significantly different at the fourth harvest, but not at the other harvests. 2H2 had significantly higher fresh and dry tap root/petioles ratios than 1L6 and 2L6.

The fresh tap root/total plant ratios were significantly different at the second and the fourth harvest, but the dry tap root/total plant ratios were significantly different only at the second harvest. At the second harvest

Table 19. The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1977 field experiment.

Line	Tap root/Leaf blades g/g/plant		Petioles/Leaf blades g/g/plant		Tap root/Petioles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H1	0.12 ab ^{6/}	0.11 a ^{6/}	0.26 a ^{6/}	0.44 a ^{6/}	0.44 a ^{6/}	0.54 a ^{6/}
1L6	0.11 a	0.10 a	0.25 a	0.45 a	0.45 a	0.54 a
2H2	0.15 b	0.15 a	0.27 a	0.57 a	0.57 a	0.70 a
2L6	0.11 a	0.11 a	0.23 a	0.47 a	0.47 a	0.68 a
Second Harvest ^{2/}						
1H1	0.61 b	0.69 a	0.77 ab	0.70 a	0.84 a	1.00 a
1L6	0.34 a	0.38 a	0.72 ab	0.63 a	0.46 a	0.61 a
2H2	0.68 b	0.81 a	0.84 b	0.83 a	0.79 a	0.94 a
2L6	0.26 a	0.39 a	0.62 a	0.71 a	0.43 a	0.53 a
Third Harvest ^{3/}						
1H1	1.62 a	1.64 a	0.91 a	0.66 a	1.82 a	2.55 a
1L6	1.31 a	1.43 a	0.96 a	0.72 a	1.37 a	1.95 a
2H2	1.47 a	1.57 a	0.84 a	0.61 a	1.80 a	2.68 a
2L6	1.06 a	1.08 a	0.74 a	0.57 a	1.46 a	1.96 a
Fourth Harvest ^{4/}						
1H1	3.35 a	4.02 a	0.82 a	0.64 a	4.06 bc	6.45 ab
1L6	2.42 a	2.95 a	0.90 a	0.64 a	2.65 a	4.61 a
2H2	3.85 a	4.12 a	0.78 a	0.52 a	4.97 c	8.11 b
2L6	2.54 a	2.91 a	0.82 a	0.59 a	2.85 ab	5.07 a
Fifth Harvest ^{5/}						
1H1	4.83 a	4.48 a	0.92 a	0.65 a	5.17 a	6.95 a
1L6	4.17 a	4.01 a	0.89 a	0.66 a	4.36 a	6.04 a
2H2	4.88 a	4.53 a	0.86 a	0.66 a	5.05 a	7.09 a
2L6	4.07 a	3.96 a	0.86 a	0.62 a	4.59 a	6.42 a

1/ The first harvest (age 25 days) was taken on June 20.

2/ The second harvest (age 47 days) was taken on July 12.

3/ The third harvest (age 68 days) was taken on August 2.

4/ The fourth harvest (age 89 days) was taken on August 23.

5/ The fifth harvest (age 109 days) was taken on Sept. 12.

6/ Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

Table 19 (Continued). The ratio of various plant parts (fresh and dry weight) of four sugar beet lines at East Lansing in 1977 field experiment.

Line	Tap root/Total plant g/g/plant		Crown/Leaf blades g/g/plant		Crown/Peti-oles g/g/plant	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}						
1H1	0.08 a ^{6/}	0.08 a ^{6/}	--	--	--	--
1L6	0.08 a	0.08 a	--	--	--	--
2H2	0.11 a	0.11 a	--	--	--	--
2L6	0.08 a	0.09 a	--	--	--	--
Second Harvest ^{2/}						
1H1	0.25 b	0.28 ab	--	--	--	--
1L6	0.16 a	0.19 ab	--	--	--	--
2H2	0.25 b	0.29 b	--	--	--	--
2L6	0.14 a	0.18 a	--	--	--	--
Third Harvest ^{3/}						
1H1	0.43 a	0.46 a	0.19 a	0.19 a	0.21 a	0.30 a
1L6	0.38 a	0.42 a	0.16 a	0.17 a	0.17 a	0.24 a
2H2	0.42 a	0.46 a	0.17 a	0.19 a	0.20 a	0.31 a
2L6	0.36 a	0.39 a	0.11 a	0.12 a	0.14 a	0.20 a
Fourth Harvest ^{4/}						
1H1	0.57 ab	0.61 a	0.57 a	0.91 a	0.70 a	1.47 a
1L6	0.51 a	0.56 a	0.42 a	0.64 a	0.47 a	1.05 a
2H2	0.61 b	0.63 a	0.57 a	0.79 a	0.73 a	1.58 a
2L6	0.53 a	0.55 a	0.42 a	0.62 a	0.51 a	1.08 a
Fifth Harvest ^{5/}						
1H1	0.61 a	0.60 a	1.18 a	1.55 a	1.28 a	2.30 a
1L6	0.60 a	0.59 a	0.84 a	1.09 a	0.94 a	1.68 a
2H2	0.63 a	0.62 a	0.92 a	1.06 a	1.01 a	1.67 a
2L6	0.60 a	0.59 a	0.86 a	1.08 a	1.05 a	1.74 a

^{1/} The first harvest (age 25 days) was taken on June 20.

^{2/} The second harvest (age 47 days) was taken on July 12.

^{3/} The third harvest (age 68 days) was taken on August 2.

^{4/} The fourth harvest (age 89 days) was taken on August 23.

^{5/} The fifth harvest (age 109 days) was taken on Sept. 12.

^{6/} Within a harvest, any two means in the same column followed by the same letter do not differ significantly at the 5 percent level of probability according to Duncan's new multiple-range test.

1H1 and 2H2 had significantly higher fresh tap root/total plant ratios than 1L6 and 2L6; 2H2 had a significantly higher dry tap root/total plant ratio than 2L6. At the fourth harvest 2H2 had the highest, whereas 1L6 and 2L6 the lowest fresh tap root/total plant ratios.

There were no significant differences between the lines in the fresh and in the dry crown/leaf blades ratios, or in crown/petioles ratios at any harvest.

Partition of Assimilates: Table 20 shows the partition of assimilates of four sugar beet lines at each harvest in 1977 field experiment.

1L6 and 2L6 had higher leaf blades percentages than 1H1 and 2H2 for each harvest. At the first harvest the partition of assimilates into leaf blades of each line was higher than the 1975 and 1976 field experiments, mainly because the plants were harvested at a younger age.

The partition of assimilates into petioles was about the same for each line at each harvest. No clear cut trends were evident from these data.

At the first harvest, 2H2 showed a higher percentage of tap root than 1H1, 1L6, and 2L6. At the last three harvests there was a trend for 1H1 and 2H2 to have higher percentages of tap root than 1L6 and 2L6.

1H1 showed higher percentages of crown at the fourth and the fifth harvest than 1L6, 2H2, and 2L6.

Table 20. Partition of assimilates (fresh and dry weight) of four sugar beet lines at East Lansing in 1977 field experiment.

Line	Leaf blades Percent		Petioles Percent		Tap root Percent		Crown Percent	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
First Harvest ^{1/}								
1H1	72.56	75.95	19.60	15.82	7.80	8.20	--	--
1L6	73.52	76.97	18.58	14.71	7.80	8.30	--	--
2H2	70.38	74.01	18.81	15.18	10.80	10.80	--	--
2L6	74.86	78.28	17.28	13.11	7.84	8.60	--	--
Second Harvest ^{2/}								
1H1	41.99	42.44	32.78	29.90	25.22	28.20	--	--
1L6	48.85	49.58	35.02	31.21	16.13	18.60	--	--
2H2	40.15	38.40	34.06	31.96	25.79	29.20	--	--
2L6	52.69	47.96	32.52	33.42	14.07	17.60	--	--
Third Harvest ^{3/}								
1H1	26.38	28.33	24.71	19.79	43.80	46.30	4.94	5.41
1L6	29.34	30.49	28.15	22.01	37.92	42.40	4.53	5.05
2H2	28.33	30.11	26.00	18.62	40.60	46.20	5.06	5.30
2L6	34.42	36.74	24.99	19.87	36.65	38.98	3.63	4.26
Fourth Harvest ^{4/}								
1H1	17.13	15.24	15.21	9.65	57.20	60.80	10.30	14.30
1L6	21.05	19.56	18.82	12.67	51.35	55.80	8.69	11.93
2H2	16.90	15.77	13.21	8.98	60.80	63.00	8.95	12.20
2L6	21.28	19.81	17.51	12.76	52.60	55.25	8.59	12.14
Fifth Harvest ^{5/}								
1H1	12.50	12.69	11.54	8.26	60.80	60.00	15.14	19.04
1L6	14.37	15.10	12.88	9.21	60.10	59.20	12.63	16.47
2H2	12.90	13.99	12.30	9.15	62.60	62.20	12.19	14.74
2L6	14.49	14.64	12.26	9.07	59.66	59.17	13.57	17.08

^{1/} The first harvest (age 25 days) was taken on June 20.

^{2/} The second harvest (age 47 days) was taken on July 12.

^{3/} The third harvest (age 68 days) was taken on August 2.

^{4/} The fourth harvest (age 89 days) was taken on August 25.

^{5/} The fifth harvest (age 109 days) was taken on Sept. 12.

SUMMARY AND CONCLUSIONS

The results of the experiments showed that in the seedling stage (24-33 days after emergence) the average TLWR of low lines was 0.12-0.20 and of high lines was 0.11-0.42. The average TLWR of the commercial hybrids was 0.20. In work by Snyder and Carlson (1978) in the growth chamber the mean TLWR of the low entries was 0.10-0.12, and the mean TLWR of the high entries was 0.16-0.20 at 21 days post-emergence. The mean TLWR of the commercial hybrids was between those two values. TLWR of both low and high lines increased as the plant aged. In the later stage of development (102-124 days after emergence) the average TLWR of low lines was 1.60-4.12 and of high lines was 2.30-4.85. The average TLWR of the commercial hybrids was 1.82.

Although there were significant differences in the ratios of the various plant parts between lines with high and low TLWR at certain harvest dates, this ratio did not affect the final tap root yield of lines with low and high TLWR. On the contrary, Snyder and Carlson (1978) reported that a sugar beet population that had a 20 percent higher TLWR at the end of the growing season yielded 23 percent more tap root weight per land area than the low TLWR population. Loach (1970) also reported that cultivars with a

larger root/shoot ratio produced greater yield than cultivars with a smaller ratio.

In the 1975 field experiment lines with low TLWR had significantly higher fresh and dry weight of leaf blades than one line with high TLWR (2H4) but this did not affect the final tap root yield. It can be concluded that beyond a certain density of foliage, nothing is gained by the plant from developing more foliage. The leaves shade each other sufficiently to prevent each leaf from receiving the maximum light intensity.

In the growth chamber Snyder and Carlson (1978) found high TLWR plants produced less fibrous roots weight than the low TLWR plants at 21 days post-emergence. The tap root to fibrous roots ratio was higher for the high TLWR selections as compared to the low TLWR selections. In a 1975 pot experiment outdoors similar results were obtained in the later stage of the development. At 124 days post-emergence one line with high TLWR (2H4) produced significantly lower fibrous roots weight than lines with low TLWR. The ratios of fibrous roots to total plant weight of 2H4 differed significantly from lines with low TLWR at 64 days and 124 days post-emergence. This is interesting since fibrous roots are required for water and mineral nutrient uptake. If someone selected for higher and higher TLWR, he might reach a point where too few fibrous roots for water and mineral nutrient uptake could adversely affect yield.

Fick et al. (1973) concluded that, in some cases, interchanging the partitioning priorities in sugar beet led to simulated plant death. For example, giving the tap root priority for reserves over fibrous roots because not enough fibrous roots were produced.

The average percentage of dry matter partitioned into various plant parts of lines with high TLWR in the seedling stage were 54.67-74.98 percent into leaf blades, 12.51-10.83 percent into petioles, 9.50-25.50 percent into tap root, and 11.03 percent into fibrous roots. Lines with low TLWR partitioned 59.80-77.62 percent into leaf blades, 10.78-31.20 percent into petioles, 7.66-14.67 percent into tap root, and 29.28 percent into fibrous roots. The average percentages of dry matter partitioned by the commercial hybrids were 65 percent into leaf blades, 19.48 percent into petioles, and 15.04 percent into tap root. In the later stage of development the average percentages of dry matter partitioned by lines with high TLWR were 12.07-25.00 percent into leaf blades, 8.70-13.90 percent into petioles, 51.00-61.00 percent into tap root, 2.75 percent into fibrous roots, and 6.99-16.89 percent into crown. Lines with low TLWR partitioned 14.87-28.36 percent into leaf blades, 9.14-17.32 percent into petioles, 45.33-59.18 percent into tap root, 3.60 percent into fibrous roots, and 7.06-16.77 percent into crown. The average percentages of dry matter partitioned by the commercial hybrids were

27.08 percent into leaf blades, 14.43 percent into petioles, 47.50 percent into tap root, and 8.27 percent into crown.

In the sugar analysis one lines with high and one with low TLWR and the commercial hybrids did not differ significantly.

LITERATURE CITED

- Booth, A., Davis, R.C., Jones, H., and F.P. Wareing. 1962. Effect of indole-3-acetic acid on the movement of nutrients within plants. *Nature* 194:204-205.
- Crafts, A.S. and C.E. Crisp. 1971. Phloem transport in plants. San Francisco, Freeman and Co. 481 p.
- Das Gupta, D.K. 1972a. Developmental physiology of sugar beet. III. Effect of decapitation, defoliation, and removing part of the root and shoot on subsequent growth. *J. Exp. Bot.* 23:93-102.
- Das Gupta, D.K. 1972b. Developmental physiology of sugar beet. IV. Effects of growth substances and differentiation root and shoot temperature on subsequent growth. *J. Exp. Bot.* 18:65-77.
- Evans, L.T. 1975. Beyond photosynthesis--the role of respiration, translocation and growth potential in determining productivity. In *Photosynthesis and productivity in different environment*, eds. J.P. Cooper, pp. 501-507. Cambridge Univ. Press.
- Follet, R.F., Schmehl, W.R., and F.G. Viets, Jr. 1970. Seasonal leaf area, dry weight, and sucrose accumulation by sugar beets. *J. Am. Soc. Sugar Beet Technol.* 16:235-252.
- Fick, G.W., Williams, W.A. and R.S. Loomis. 1973. Computer simulation of dry matter distribution during sugar beet growth. *Crop Sci.* 13:413-417.
- Geiger, D.R., Saunders, M.A., and D.A. Cataldo. 1969. Translocation and accumulation of translocate in the sugar beet petiole. *Plant Physiol.* 44:1657-1665.
- Hew, C.S., Nelson, C.D., and G. Krotkov. 1967. Hormonal control of translocation of photosynthetically assimilated ^{14}C in growing soybean plant. *J. Am. Bot.* 54: 252-256.

- Humphries, E.C., and S.A. French. 1969. Photosynthesis in sugar beets depends on root growth. *Planta* 88: 87-90.
- Habeshaw, D. 1973. Translocation and the control of photosynthesis in sugar beet. *Planta* 110:213-226.
- Jones, H., Martin, R.V., and H.K. Porter. 1959. Translocation of ^{14}C carbon in tobacco following assimilation of ^{14}C carbon dioxide by a single leaf. *Ann. Bot.* 23: 493-508.
- Joy, K.W. 1964. Translocation in sugarbeet. I. Assimilation of $^{14}\text{CO}_2$ and distribution of materials from leaves. *J. Exp. Bot.* 15:485-494.
- Jenner, C.F., and A.J. Rathjen. 1972. Limitation to the accumulation of starch in the developing wheat grain. *Ann. Bot.* 36:743-754.
- Kursanov, A.L. 1963. Metabolism and the transport of organic substances in the phloem. *Advan. Bot. Res.* 1: 209-278.
- Kvet, J., Ondok, J.P., Necas, J., and P.G. Jarvis. 1971. Methods of growth analysis. In *Plant photosynthetic production. Manual of methods*, eds. Z. Sestak, J. Catsky, and P.G. Jarvis, pp. 343-382. Dr. W. Jung N.V. Publ., The Hague, Netherland.
- Luckwell, L.C. 1960. The physiological relationship of root and shoot. *Sci. Hort.* 14:22-26.
- Loah, K. 1970. Analysis of differences in yield between six sugar beet varieties. *Ann. Appl. Biol.* 66:217-223.
- Loomis, R.S., Ulrich, A., and N. Terry. 1971. Environmental factors. In *Advances in sugar beet production. Principles and practices*, eds. R.T. Johnson, J.T. Alexander, G.E. Rush, and G.R. Hawkes, pp. 20-48. The Iowa Univ. Press.
- Little, C.H.A., and K. Loach. 1973. Effect of changes in carbohydrate concentration on the rate of net photosynthesis in mature leaves of Abies balsamea. *Can. J. Bot.* 51:751-758.
- Mothes, K. and L. Engelbrecht. 1961. Kinetin-induced directed transport of substances in excised leaves in the dark. *Phytochem.* 1:58-62.

- Maggs, D.H. 1963. The reduction in growth brought about by fruiting. *J. Hort. Sci.* 38:119-128.
- Moorby, J. 1964. The foliar uptake and translocation of Caesium. *J. Exp. Bot.* 15:457-469.
- Mortimer, D.C. 1965. Translocation of the product of photosynthesis in sugar beet petioles. *Can. J. Bot.* 43:269-280.
- Milthorpe, F.L., and J. Moorby. 1969. Vascular transport and its significance in plant growth. *Ann. Rev. Plant Physiol.* 20:117-138.
- Mullins, M.G. 1970. Hormone-directed transport of assimilates in decapitated internodes of Phaseolus vulgaris L. *Nature* 194:204-205.
- Meidner, H. 1970. Effect of photoperiodic induction and debudding in Xanthium pennsylvanicum and of partial defoliation in Phaseolus vulgaris on rates of net photosynthesis and stomatal conductances. *J. Exp. Bot.* 15:457-469.
- Patrick, J.W. 1972a. Vascular system of the stem of the wheat plant. II. Development. *Aust. J. Bot.* 20: 65-78.
- Patrick, J.W. 1972b. Distribution of assimilate during stem elongation in wheat. *Aust. J. Biol. Sci.* 25: 455-467.
- Steel, R.G.D., and J.H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., Inc. New York.
- Shiroya, M., Nelson, C.D., and G. Krotkov. 1961. Translocation of ^{14}C in tobacco at different stages of development following assimilation of $^{14}\text{CO}_2$ by a single leaf. *Can. J. Bot.* 39:855-864.
- Sweet, G.B., and F.P. Wareing. 1966. Role of plant growth in regulating photosynthesis. *Nature* 210:77-79.
- Swanson, C.A., and D.R. Geiger. 1967. Time course of low temperature inhibition of sucrose translocation in sugar beet plant. *Plant Physiol.* 42:751-756.
- Seth, A.K., and P.F. Wareing. 1967. Hormone directed transport of metabolites and its possible role in plant senescence. *J. Exp. Bot.* 18:65-77.

- Shiroya, M. 1968. Comparison of upward and downward translocation of ^{14}C from a single leaf of sunflower. *Plant Physiol.* 43:1605-1610.
- Snyder, F.W., and G.E. Carlson. 1978. Photosynthate partitioning in sugar beet. *Crop Sci.* 18:657-661.
- Silvius, J.E., Kremer, D.F., and D.R. Lee. 1978. Carbon assimilation and translocation in soybean leaves at different stages of development. *Plant Physiol.* 62: 54-58.
- Thaine, R., Ovenden, S.L., and J.S. Turner. 1959. Translocation of labelled assimilate in soybean. *J. Biol. Sci.* 12:349-372.
- Thrower, S.L. 1962. Translocation of labelled assimilates in the soybean. II. The pattern of translocation in intact and defoliated plant. *Aust. J. Biol. Sci.* 15: 629-650.
- Thorne, G.N., and A.F. Evans. 1964. Influence of tops and roots on net assimilation rate of sugar beet and spinach beet and grafts between them. *Ann. Bot.* 28: 499-508.
- Thorne, G.N., Ford, M.A., and D.J. Watson. 1967. Effects of temperature variations at different times on growth and yield of sugar beet and barley. *Ann. Bot.* 31: 71-101.
- Trip. P. 1969. Sugar transport in conducting elements of sugarbeet leaves. *Plant Physiol.* 44:717-725.
- Winter, H., and D.C. Mortimer. 1967. Role of the root in the translocation of product of photosynthesis in sugar beet, soybean, and pumpkin. *Can. J. Bot.* 45: 1811-1823.
- Wardlaw, I.F. 1968. The control and pattern of movement of carbohydrate in plant. *Bot. Rev.* 34:79-105.
- Wareing, P.F., Khalifa, M.M., and K.J. Treharne. 1969. Rate limiting processes in photosynthesis at saturating light intensities. *Nature* 220:453-457.
- Watson, D.J. 1971. Size, structure, and the activity of the productive system of crops. In *Potential crop production*, eds. F.P. Wareing, and J.P. Cooper, pp. 76-88. London, Heinemann.

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