Euphytica 1 (1952): 201–211

SOME FACTORS IN THE GROWTH RATE OF RED GARDEN BEETS

O. BANGA
Institute of Horticultural Plant Breeding, Wageningen
Received May 6th, 1952

CONTENTS

1. INTRODUCTION

In breeding red beets productivity, as determined by the total weight of the roots harvested per unit of area, is not an actual purpose. For the total root weight is the number of roots × the average root weight, but the average root weight is chosen in accordance with the intended use of the roots, while the number of roots per unit of area is adjusted to the intended weight of the individual roots at harvest time, by planting narrower or wider.

If one factor increases, the other one decreases. So the total weight per unit of area does not vary considerably. More interesting is the time necessary to reach the desired root weight, that is the growth rate of the roots, and the reliability of this growth rate under different conditions.

2. DIFFERENT LEVELS OF FOLIAGE EFFICIENCY

It is well known that in every root crop there are types with small tops, and other ones with larger tops, and that sometimes the small tops produce as large a root or even a larger one in the same time as the larger tops. This suggests that in this respect there may be different levels of foliage efficiency.

As an indicator of this type of foliage efficiency we have calculated the average foliage weight per 100 grams of root. The smaller this value, the higher the foliage efficiency is.

Of course, this is an indicator which is changing during the growing period of the plants. In the case of beets, the foliage increases till the first half of August, then it gradually decreases. The root starts its development later than the foliage, but may continue its increase till the end of the season. Consequently, the foliage weight per 100 g of root decreases very quickly during the first part of the growing season, and later more slowly.

Nevertheless, if in Holland beets are planted between the end of April and the beginning of June, and they are harvested between the end of July and the end of August, good comparative values are usually obtained for different types. To be comparable in any individual case, the types must of course be planted and also harvested at the same time.

In a great many trials during the years 1942–1948 it was found that different varieties and very often even different strains within varieties have a constant place as to the relative level of foliage efficiency.

Roughly a classification after four levels of efficiency could be made. The highest level (that is the lowest value of the foliage weight per 100 g of root) is called level I. The lowest level is called level IV. There are some very unproductive varieties which might be classified in a still lower level, but they have not been studied further.

Usually the levels I, II + III, and IV can easily be distinguished. The levels II and III very often can be separated, but sometimes not.

The supposition of the existance of four levels is a tentative one, as long as the genetical basis is not known. It may prove that the genetical variation of the efficiency is in reality continuous, but it is also possible that making the strains homozygous for their degree of foliage efficiency would effectuate a cleaner separation of the different levels. Anyway there are strains now, which take more or less an intermediate position between two of the indicated levels.

The groups of the Egyptian types, of Crosby and Early Wonder, and of the Detroit types all have representatives of the levels II, III and IV. Moreover we found two Egyptian types of level I, and one Crosby, which was intermediate between the levels I and II.

3. Foliage weight per plant and foliage efficiency

In general, varieties with a low foliage efficiency (level IV) have a large top, and varieties with a short top have a high foliage efficiency (level I). This is understandable, for besides the foliage efficiency the foliage weight per plant is a factor in the growth rate of the root. Between certain limits the root weight is proportional to the foliage weight per plant. Consequently a plant with a low level of foliage efficiency only grows fast enough if it has a large top; a plant with a short top only can develop a sufficient growth rate of the root, if the level of foliage efficiency is high. Plants with a combination of a low foliage efficiency and a short or a medium top will grow very slowly, and therefore will have little chance to survive the hand of the breeder.

Nevertheless there are some varieties with a low foliage efficiency and a medium top, and consequently with a very slowly growing root (e.g. some round dark-leaved types), but they are of no importance whatever for vegetable growers.

Among the varieties with a medium foliage efficiency (levels II and III) there are several variations in foliage weight per plant.

Though we find very often the same combinations between a certain level of foliage efficiency and a certain amount of foliage, the conclusion is, that a high foliage efficiency is not necessarily associated with a small top, and that a low efficiency does not always mean that the top is large, but that foliage efficiency and foliage weight per plant are two separate characters which can be combined in different ways.

4. Some examples

In figures 1 and 2 some examples are given of curves for average foliage weight per 100 g of root, average foliage weight per plant and average root weight of some types, as found in experiments 48 C and 48 D.

48 C and 48 D were randomized block experiments with 5 successive harvests, each in 5 replications, planted April 29 and May 1 respectively, harvested successively on July 14, July 28, August 11, August 25, September 29, and on July 21, August 4, August 18, September 1, September 15, respectively. The number of plants per plot was 50. The planting distance was 25 × 20 cm.

In the upper part of fig. 1 we find the curves of the average foliage weight per 100 g of root of a Perfected Detroit (IV^1), of a Round Dark Leaved (IV^2), and of two Detroits (III and II). The Roman numerals indicate the levels of foliage efficiency, and at the same time the varieties or strains, which have been chosen as representatives of those levels. In the middle part of fig. 1 we see the curves of the foliage weight per plant, and in the lower part those of the root weight.

Varieties IV^1 and IV^2 have the same foliage efficiency. IV^1 has a large top, IV^2 a medium one. The root growth of IV^2 is much slower than that of IV^1.

IV^1 has more foliage than III, but it is not enough to counterbalance its lower efficiency. Consequently the growth rate of the root of III is higher than that of IV^1. The same is true for the relation of IV^1 and II.

II has a higher foliage efficiency than III, but III has more foliage than II. In four of the five successive harvests their root weights were nearly the same. So under the conditions of this experiment the growth rate of their roots cannot have differed very much.

The curves for root weight of the varieties in fig. 1 do not intercross; they run more or less parallel during the whole season.

In fig. 2 IV represents a Crosby, III and II two strains of the ordinary Flat Egyptian, and I a short-top Egyptian type, called Gladoro.

II and III have practically the same amount of foliage. In the field they look quite similar. But II has a higher foliage efficiency; consequently its root growth is faster. The curves for root growth of II and III keep on a more or less parallel course during the whole season.

I and IV show a different picture. I has very little foliage, but in the beginning it has the fastest root growth of all four varieties. Later its growth rate decreases more than that of any of the other varieties. IV has a large top. Its root growth starts slowly, but later in the season it increases so much, that it surpasses that of all the other varieties. The curve for root growth of IV not only crosses that of I, but also that of II.

5. A large top has no advantages in withstanding dry relatively cold weather conditions

In general it is expected that a plant with a large top will stand unfavourable growth conditions better than a short-top plant.

In 1949 some experiments were made to test this point. The same series of varieties was grown on a good silt soil at two places under the northern sea embankment of the provinces Groningen and Friesland (places 7 and 8), on a heavy silt soil in the N.E. polder (place 6), on a heavy clay soil 30 km from Wageningen (place 5), on a very dry sandy soil near Wageningen (place 4), and on a low sandy soil with plenty of water in the subsoil near Wageningen (place 1). At each of these places the varieties were grown in a randomized block experiment with 4 replications (Exp. 49 D).

The year 1949 happened to be favorable for this experiment, for it was exceptionally cold during the months of May and June, and during the first decade of July and the first and second decade of August. The greater part of the growing season of the red beets was also very dry. Places 7 and 8 were most of the time 1 or 2 °C colder than places 1, 4 and 5, but they had a little more rain. Place 6 had nearly the same temperature as places 7 and 8, but had about the same quantity of rain as places 1, 4 and 5. Place 1 never had a shortage of water in the subsoil. Place 4 was certainly too dry for a normal growth of the plants. On place 5 the heavy clay was most of the time hard and cracked because of the dryness. The first part of the growing season expecially displayed unfavourable growth conditions for the red beets.

From the nine varieties which were grown in this experiment I take the date of three varieties, which show great differences in the amount of their foliage. They were a typical short top Egyptian, a medium top one, and a typical large top Egyptian.

In table 1 the foliage weight per 100 g of root and the root weight after 101 days of growth are given and in addition the average dry matter content in percentages of the fresh root weight.

The root weights of the places 1, 7 and 8 were of the same order. Also those of the places 4 and 6. This proves that the difference in temperature of 1 or 2 °C was under these conditions of less consequence than the difference in available water. As they were of the same order, the average of the root weights of the places 1, 7 and 8 is given and also the average of the places 4 and 6. The average root weights of the places 1, 7 and 8 are put as 100; those of the places 4 and 6, and those of place 5 are calculated as a percentage of those of the averages of the places 1, 7 and 8.

TABLE 1. GROWTH OF THREE EGYPTIAN TYPES ON DIFFERENT PLACES

Type of Egyptian	No	Foliage weight per 100 g of root (g)			Index-values of average root weight; between brackets actual av. wghts. in g			Dry matter content of roots in °/₀ of fresh weight		
		1,7,8	4.6	5	1,7,8	4,6	5	1,7,8.	4,6	5
Short top	49119	48	43	36	100 (353)	49	37	10.2	11.2	13.6
Medium top	49008	75	70	54	100 (329)	52	38	11.0	12.6	14.7
Large top	49010	135	144	115	100 (277)	46	33	10.8	13.6	18.0

In addition to the differences between the amounts of foliage of the three types there are great differences in foliage efficiency, as can be seen in table 1 (see foliage weight per 100 g of root).

The root weights of the different places show great differences.

Places 4 and 6 give about half the root weight of that of the places 1, 7 and 8. Place 5 evidently had the worst growth conditions, for here the root weight is still more reduced. The reduction of the root weight of the short top and the medium top types is about the same. The reduction of the root weight of the large top type certainly is not less than that of the two other types. If there is a difference, the root weight of the

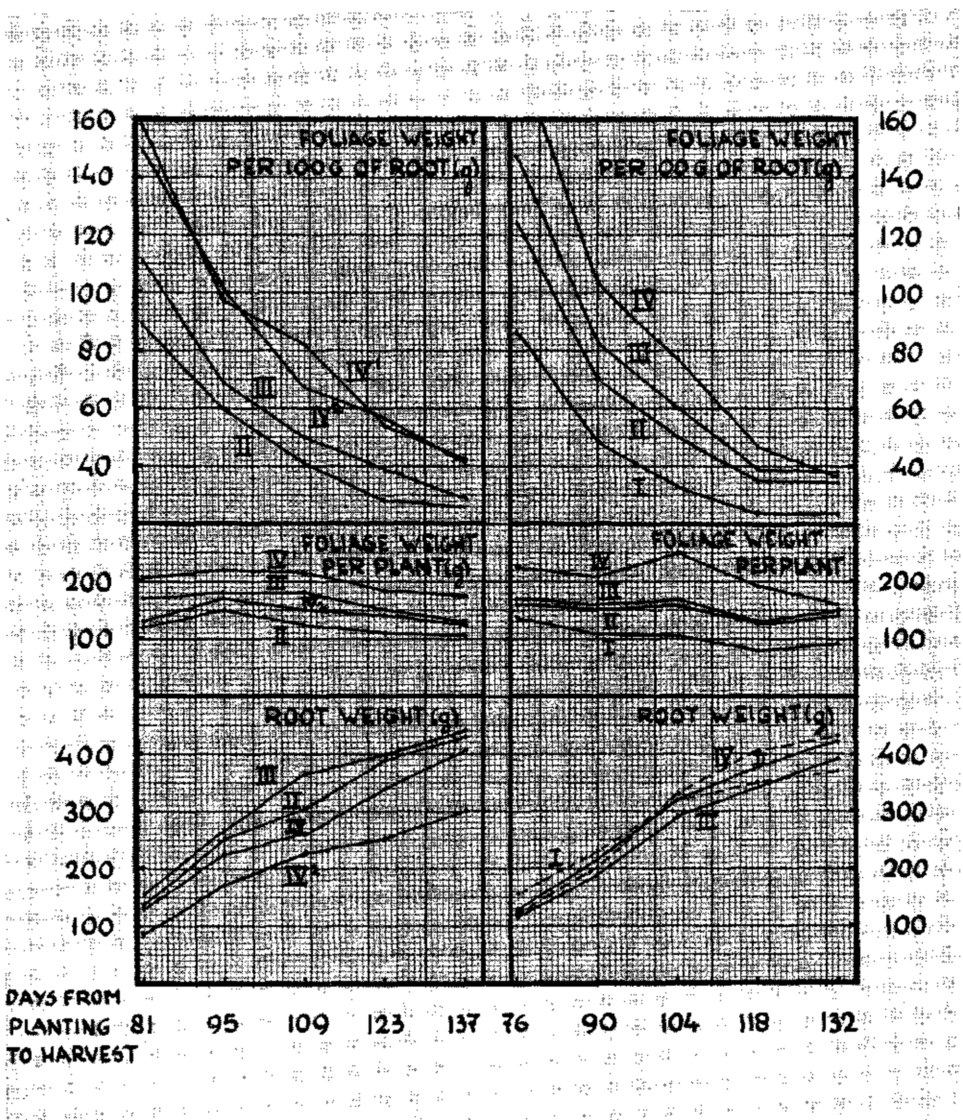

FIG. 1 AND 2. THE CURVES FOR THE FOLIAGE WEIGHT PER 100 GRAMS OF ROOT, THE FOLIAGE WEIGHT PER PLANT AND THE ROOT WEIGHT OF SOME DIFFERENT VARIETIES OF THE RED GARDEN BEET.

Fig. 1. Varieties (exp. 48 D):
- IV[1] Perfected Detroit 47435
- IV[2] Round Dark Leaved 48045
- III Detroit 48002
- II Detroit 48056

Fig. 2. Varieties (exp. 48 C):
- IV Crosby 48024
- III Flat Egyptian 48044
- II Flat Egyptian 48004
- I Short-top Egyptian 48057

large top type is reduced most. The average dry matter content of the roots of the medium and the large top types was about the same when grown on the places 1, 7, 8 (11.0 en 10.8 % respectively). But that of the large top type has increased more than that of the medium top type, when grown on the places 4, 6 (12.6 and 13.6 % respectively), and still more when grown on place 5 (14.7 and 18.0 % respectively). This suggests that indeed the root growth of the large-top type had slowed down more than that of the medium-top type under the unfavourable growth conditions.

So we may conclude that a short top with a high foliage efficiency is not a handicap in dry and cold weather, and that a large top of low efficiency certainly has no advantages under such conditions.

6. Influence of dry hot weather on the foliage: root ratio

We also had the opportunity to make some observations on the influence of dry hot weather on the growth of red beets. The season of 1947 was for the Netherlands exceptionally dry and hot. It had quite a continental character, whereas usually the weather is relatively cool and wet. The growing seasons of 1946 and 1948 were of the normal maritime character.

The Egyptian strain EgF–S & G was grown in randomized block experiments in the three successive seasons of 1946, 1947 and 1948. These experiments were indicated as 46 E, 47 A and 48 C respectively. The planting and harvest dates were as is given in table 2.

Table 2. Planting and harvest dates of EgF–S & G in 1946, 1947, 1948

Experiment	Planting date	Successive harvest dates
46 E	May 15	7–25, 8–17, 9–4, 9–26, 10–17
47 A	May 14	7–1, 7–15, 7–29, 8–12, 8–26, 9–9
48 C	April 29	7–14, 7–28, 8–11, 8–25, 9–8

The soil on which the plants were grown had all the time a good water supply from the subsoil, in 1947 as well as in the other seasons, and never was too wet either. In the dry season of 1947 after August 12 evidently the water intake from the soil could not keep up with the transpiration of the leaves in the dry air. After that date the plants showed some wilting until on September 6, 7 and 8 there came some rain (on the 115th, 116th and 117th day after planting).

The curves for average foliage weight per 100 g of root, average foliage weight, and average root weight for the three seasons are given in fig. 3. They are plotted against the number of days from the date of planting to that of harvesting in each individual experiment.

We see that in 1946 and 1948 the curves for foliage weight per 100 g of root are practically the same, but in 1947 it shows a much quicker decline than in 1946 and 1948.

The middle part of fig. 3 shows that the foliage curve of 1947 is well below the curves of 1946 and 1948, which are both of the same height. After the rains of the 115th, 116th and 117th days after planting in 1947 the foliage weight increases very rapidly.

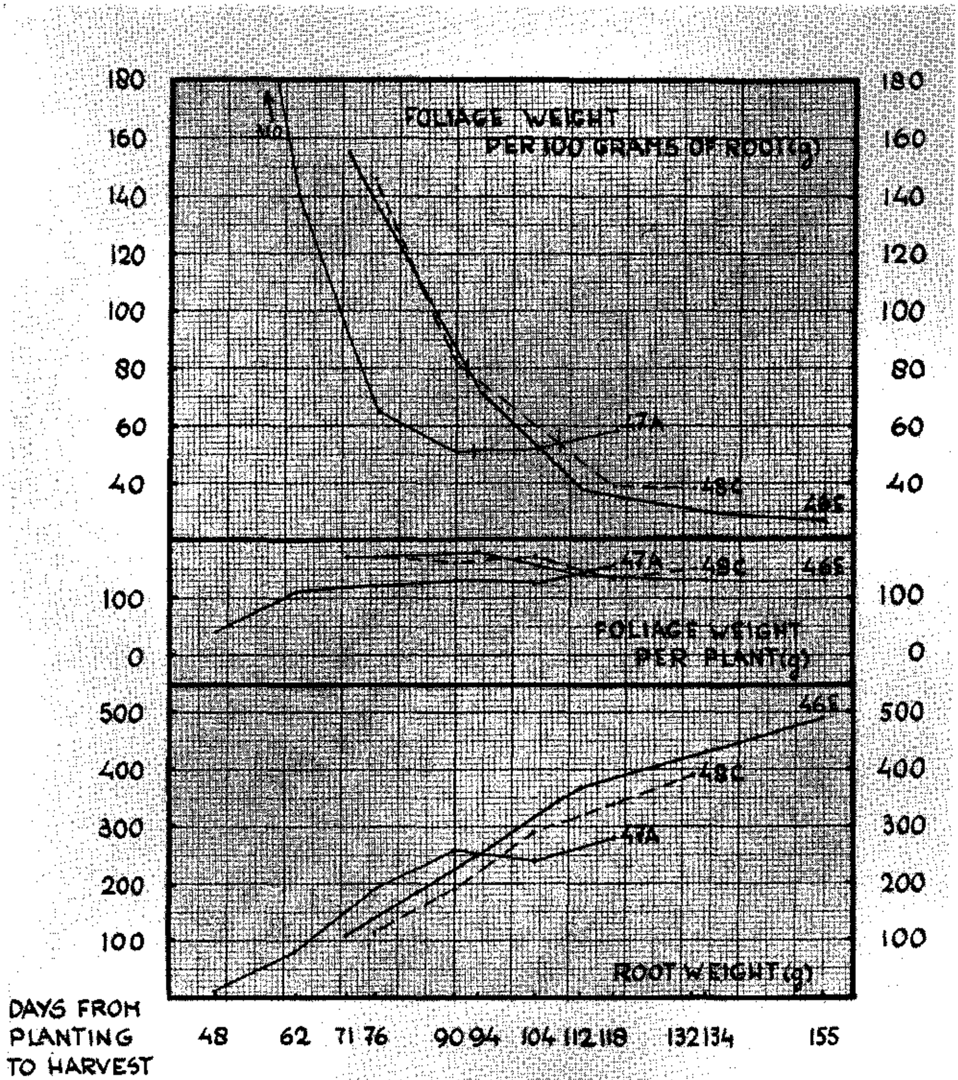

FIG. 3. THE CURVES FOR THE FOLIAGE WEIGHT PER 100 GRAMS OF ROOT, THE FOLIAGE WEIGHT PER PLANT AND THE ROOT WEIGHT OF THE FLAT EGYPTIAN EgF–S & G IN 1946 (46 E), IN 1947 (47 A) AND 1948 (48 C). THE GROWING SEASONS OF 1946 AND 1948 WERE COOL AND RELATIVELY WET, BUT THE SEASON OF 1947 WAS EXCEPTIONALLY DRY AND WARM.

This may be just the difference in water content of the foliage.

In the lower part of fig. 3 the curves of the average root weight are shown. The curve in 1947 during the first two weeks might be a prolongation of the curve of 1946. It follows the same course. The experiments 46 E en 47 A were planted at practically the same time (on May 15 and May 14 respectively). So this is what we may expect, if the seasons are not too different. But after the 62nd day the curve of 47 A rises above the course of the curve of 46 E, until after the 90th day the root cannot maintain its water content, and it consequently does not gain more weight. After the three days of rain, mentioned above, the root weight increases, possibly only because of the greater water content.

The interesting point is, that the foliage in the warm summer of 1947 is smaller than in the cool seasons of 1946 and 1948, and that the root is growing faster. The last decade of July and the whole month of August in 1947 were much warmer than they were in 1946. This is just the time that the growth rate of the root was higher than in 1946.

So there is a strong indication that it is the higher temperature which has caused the quick decline of the curve of the average foliage weight per 100 g of root, by reducing the foliage growth and accelerating the growth of the root.

This is corroborated by results from a simple experiment (49 M), in which equal lots of plants in a frame were covered by sashes every 24 hours during 0, 10, 14 or 18 hours. In the last three instances the sashes were over the plants from 9 p.m.–7 a.m., from 5 p.m.–7 p.m., and from 1 p.m.–7 a.m. respectively. The longer the plants were covered by the sashes, the more warmth they had. The temperatures were measured only during the period from July 12 to August 5. During the foregoing period the differences may have been greater.

TABLE 3. BEHAVIOUR OF EGF–S & G WHEN COVERED BY SASHES DURING DIFFERENT PERIODS PER 24 HOURS. SEEDS PLANTED MAY 18. TREATMENT STARTED JUNE 19. HARVESTED AUGUST 5.

Covered by sashes every 24 hours during	0 hours	10 hours	14 hours	18 hours
Av. daily max. temp. from July 12–August 5 . .	24.3 °C	24.9 °C	25.7 °C	28.8 °C
Av. daily min. temp. from July 12–August 5 . .	12.8 °C	14.3 °C	14.3 °C	14.8 °C
Av. fol. wght. (g) per 100 g of root	115	129	102	100
Av. fol. wght. per plant (g)	203	224	213	184
Av. root wght. (g)	177	174	209	184
Dry matter content of root in % of fresh weight	9.9	9.3	8.6	8.3

According to the behaviour of some other varieties in the same experiment the root weight with covering by sashes during 10 hours should have been higher than with covering during 0 hours. As this experiment comprised no replications this irregularity is not amazing. If we compare the coverings during 0, 14 and 18 hours, we see, that some increase of temperature (covered during 14 hours) results in more foliage and a higher root weight, but the root weight has increased more than the foliage weight, which is indicated by the fact that the foliage weight per 100 g of root has dropped from 115 g to 102 g. When the temperature is still higher both the foliage weight and the root weight are smaller. The dry matter content of the root is lower the higher the temperature is.

Combining the results of the experiments 46 E, 47 A, 48 C and 49 M, we get the impression, that high temperature induces an earlier root thickening than low temperature, but that the root also is sooner ripe, with the consequence, that its growth rate sooner slows down. As high temperature also causes the foliage to be smaller, especially if the atmosphere is dry, in a warm continental climate a large-top type that naturally reaches its ripeness not too soon will have advantages over a small or even a medium-top type that naturally ripens in a short time. For in a continental climate the short-top type will easily make too little foliage and a very small root, whereas the late ripening large-top type can very well stand some reduction of its foliage weight and some acceleration of its ripening.

7. The physiological type as indicated by the potash content of foliage and root

It is known that the ratio of the potash content of the foliage and that of the root plays an important part in sugar-beet plants (3, 4) and that this ratio can be used in sugar-beet breeding as an indicator of the physiological type of the plant (5).

The potash content of the foliage may be called K^f and that of the root K^r. If the ratio K^f/K^r is low, the root has a relatively low sugar content; if this ratio is high, its sugar content is relatively high. Further there is a negative correlation between sugar content and growth rate of the root; it has never been possible to combine a high sugar content and a high growth rate of the root in one variety.

So we get: low value of K^f/K^r means high sugar content and low growth rate of the root; high value of K^f/K^r means low sugar content and high growth rate of the root.

It is supposed, that the K^f/K^r ratio has something to do with the distribution over the foliage and the root of the sugar which is formed in the leaves. If the ratio is low a great part of the sugar will stay in the foliage, and be used for growth, so the growth rate will be relatively high. If the ratio is high much more sugar will go to the root to be stored, and consequently it cannot be used for growth, so the growth rate is relatively low.

We found Mr A. J. Th. Hendriksen of D. J. van der Have Seed Co, Kapelle-Biezelinge, prepared to determine the potash contents of the foliage and the root of a series of red beet varieties, by means of his flame photometer.

The results were as indicated in table 4.

In table 4 the varieties have been arranged according to this K^f/K^r value. From top to bottom they increase. At the same time the average root weights decrease from top to bottom, with one exception.

The exception is formed by Medium-top Egyptian No 49007. But with this variety there evidently is something wrong. In earlier experiments its level of foliage efficiency was II, but in this experiment its foliage weight per 100 g of root does place it on the same level as the numbers 49022 and 49016, that is level IV. So, after the earlier experiences, with a foliage weight of 184 g per plant, its root weight should indeed have been higher than it was in this experiment. As the reason of the different behaviour of this variety in 1949 is not known, we can better discard this variety for the moment.

Large-top Crosby 49071 had not been in earlier experiments. So there was no previous experience on its foliage efficiency. But the level of this efficiency is certainly IV.

The numbers 49119 and 49017 (Short-top Egyptian and Short-top Crosby) have somewhat the same foliage weight per plant. But K^f/K^r of 49119 is lower than that of 49017. So the root weight of 49119 is higher than that of 49017.

TABLE 4. THE RATIO K^f/K^r OF SOME RED BEET VARIETIES IN COMPARISON WITH SOME OTHER CHARACTERS OF THESE VARIETIES IN 1949 (EXP. 49 F)

Variety	No	Root		Fol. effic. in earlier experi-ments	Fol. wght. 100 g of root on August 10 (g)	K^f/K^r	Foliage weight per plant (g)
		av. weight (g)	dry matter (% of fresh) matter				
Short-top Egyptian	49119	260	10.2	I	52	1.22	135
Short-top Crosby	49017	238	10.8	I–II	58	1.29	137
Large-top Crosby	49071	231	11.6		108	1.42	247
Medium-top Egyptian	49007	199	11.0	II	98	1.64	184
Large-top Crosby	49022	230	11.6	IV	92	1.80	225
Perfected Detroit	49016	197	13.2	IV	93	1.89	193

The numbers 49071, 49022 and 49016 form a group of varieties with a low foliage efficiency (level IV). No 49071 has a lower value of K^f/K^r and more foliage than No 49022. So we should expect No 49071 to have a larger root than No 49022. But their root weights are the same. If we use the foliage weight per 100 g of root on August 10 as an indicator of foliage efficiency, it seems that the foliage efficiency of No 49071 is less than that of 49022. On this basis it would be understandable that a variety with more foliage of a lower efficiency gives the same root weight as a variety with less foliage of a little higher efficiency. As the value of this indicator is very much dependant on the age of the plants, and, after the experiences with sugar beets, the value of K^f/K^r less so, No 49071 might have the potentiality of a higher growth rate than No 49022, but being of a coarser, later ripening type than No 49022, No 49071 may show it only after a longer youth period.

Large-top Crosby 49022 has more foliage than Perfected Detroit 49016, but of about the same efficiency. So 49016 has a smaller root than 49022. The value of K^f/K^r of 49016 is a little higher than that of 49022. Also its dry matter content as a percentage of the fresh root is higher. If we look over the whole of table 1 we see that the general trend is, that a low value of K^f/K^r is correlated with a low dry matter content, and a high value of K^f/K^r with a high dry matter content.

With the experience with sugar beets as a background, it seems rather safe to conclude, that the ratio K^f/K^r may be a useful indicator of the physiological type of red beets, in addition to the other characters, especially if one has to judge inbred strains.

8. SUMMARY

1. The determination of the growth rate of the roots and of the reliability of this growth rate under different conditions are important preambles in the breeding work of red beets. The results of some randomized block experiments are described, from which conclusions are drawn as to some factors which are useful in the selection for growth rate.
2. The growth rate of the root is governed to a large extent by the foliage type; factors herein are the foliage efficiency and the amount of foliage per plant. As an indicator of foliage efficiency the foliage weight per 100 grams of root is used. Some examples of the growth rate of the root of varieties with a different foliage

efficiency and a different foliage weight per plant are given (fig. 1 and 2).

3. A large top of low efficiency does not make a plant more resistant to reduction of the growth rate in dry and cold weather than a short top. Indeed a short-top type showed a greater resistance than a large-top type (table 1).
4. In dry hot weather a large-top type that naturally ripens relatively late may be more satisfactory than a short-top type that naturally ripens relatively early, for high temperature causes the foliage to be smaller and accelerates the ripening of the root (fig. 3 and table 3).
5. A low value of the ratio of the potash content of the foliage to the potash content of the root seems to indicate a type that has the potentiality of a high growth rate and a relatively low dry matter content of the root, whereas a high value of this ratio seems to indicate the reverse (table 4).

9. Samenvatting

Enkele factoren in de groeisnelheid van rode bieten

1. De groeisnelheid van de knol en de betrouwbaarheid van de groeisnelheid onder verschillende omstandigheden is een belangrijk gezichtspunt in het veredelingswerk bij kroten. Er worden enige proeven beschreven, uit welker resultaten conclusies worden getrokken t.a.v. de selectie op groeisnelheid.
2. De groeisnelheid van de knol wordt voor een groot deel beheerst door het looftype; hierin spelen de loofprestatie en het loofgewicht per plant een rol. Als indicator van de loofprestatie wordt het loofgewicht per 100 g knol gebruikt. Er worden enige voorbeelden gegeven van de groeisnelheid van de knol van rassen met een verschillend niveau van loofprestatie en een verschillende hoeveelheid loof (fig. 1 en 2).
3. Een zwaar loof met een gering prestatievermogen maakt een plant niet resistenter tegen droog en koud weer, dan een kort loof met een groot prestatievermogen. In feite werd de groeisnelheid van een kortlooftype door droogte en koude minder geremd dan die van een type met extra zwaar loof (tabel 1).
4. In droog warm weer zal een zwaarlovig, van nature laat rijpend, type meer voldoening geven dan een kortloof type dat van nature vroeg rijp is, want hoge temperatuur veroorzaakt een kleiner loof en een versnelde rijping van de knol, waardoor deze zich wel vroeger ontwikkelt, maar kleiner blijft (fig. 3 en tabel 3).
5. Een lage waarde van de verhouding van het kaliumgehalte van het loof tot het kaliumgehalte van de knol schijnt een type aan te wijzen dat de mogelijkheid van snelle groei en een betrekkelijk laag droge stof gehalte inhoudt, terwijl een hoge waarde van deze verhouding typisch schijnt te zijn voor het omgekeerde (tabel 4).

10. Literature cited

1. Banga, O., Krotenstudies VI, VII. I.V.T. Med. **19** (1950): 1–79.
2. ——, Is de verhouding K-loof : K-knol een bruikbare indicator bij de selectie op groeisnelheid van de knol? Jaarverslag I.V.T. **1** (1951): 47–48.
3. Ginneken, P. J. H. van, Onderzoek omtrent de minerale samenstelling van loof en wortel van suikerbieten. Instituut voor Suikerbietenteelt. Med. **9** (1939): 31–132.
4. ——, De onderscheiding van suikerbietenrassen op grond van de minerale samenstelling van loof en wortel. Instituut voor Suikerbietenteelt. Med. **10** (1940): 179–276.
5. Hendriksen, A. J. Th., Het gebruik van enkele correlaties bij de bietenveredeling. Voordracht Studiekring voor Plantenveredeling, 10 April 1951. (This paper read at the Study Centre of Plant Breeding will be published in the English language in the next number of Euphytica.)