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CORRELATIONS BETWEEN PLANT WEIGHT CHARACTERISTICS OF YOUNG TOMATO PLANTS

P.J.A.L. de Lint and D. Klapwijk
Glasshouse Crops Research and Experiment Station,
Naaldwijk, The Netherlands.

Abstract

Successive harvests were performed in a large number of propagating experiments with tomato seedlings. Various characteristics of the harvested plant material were determined to describe the growth performance of the plants and to describe the change in relative importance of different plant parts during growth.

Fresh and dry weight of the total shoot and of leaves separately were determined over a wide range of growing procedures and of greenhouse conditions.

Dry matter production can be satisfactorily determined by fresh weight measurement, both for shoot and leaves. Also the amount of leaf material can be determined from its relation with total shoot fresh weight.

It seems that the relation between characteristics can only be properly described by the slope of the functions and not by relative percentages, unless one is sure that the curve passes through the origin.

Introduction

Over a period of five years, propagating experiments were performed to study the growth of tomato seedlings in pots under Dutch glasshouse conditions. In all seasons, sowings were made to obtain information about relative potentials of growth in the various months of the year. For this reason, from each sowing, plants were harvested at intervals from germination until flowering of the first or second truss. Data observed, among others, were fresh and dry weights of shoots and of leaves separately.

These data can be used to construct growth rate curves(de Lint and Klapwijk, 1973) and to study plant quality aspects as functions of season, growing procedure and plant size or age. In this paper, quality aspects will be discussed.

Material and methods

Tomato cv 'Moneymaker' was directly sown in pots. Upon germination, plants that appeared on one specific day were maintained. Too early and late ones were discarded. Pots were filled with commercial potting compost, or with a coarse type of sphagnum peat. Pot types and pot sizes varied from about 0.1 L to 10 L for plastic pots and in some experiments soil blocks were included. Watering and application of fertilizer was also quite different from one experiment to the next, from hand watering to a practically full-automatic hydroponic procedure.

Light and temperature conditions varied with the season. The setting of controls was as much as possible according to practice prescription. Thermohygrograph sheets are available. Distances between plants were such that mutual shading remained very limited when the plants grew larger. Normally, of 100 g plants (beginning of flowering stage) 8 plants were put in 1.5 m^2 trays.

At harvest, plants were cut just below the cotyledons for weighing. Leaves were stripped by hand roughly to separate leaf blades from stem and thicker petioles. Stems and leaves were weighed separately, dried and weighed again. The number of plants used per harvest depended on the size of the plants. For very young stages some 25 plants were used, whereas, for the later stages usually 4 plants were taken.

The data presented are taken from 82 harvests in some 20 experiments. Growth rates of some of the experiments used are presented in figure 1, to show the effect of the great differences in growing conditions used. For smaller plants shoots and leaves could not be properly separated. Therefore, in this paper data are taken only from plants of about 1 g fresh weight and larger.

Results

The relation between dry and fresh weight of the shoots of 82 harvests from experiments grown under the range of experimental conditions described, is shown in figures 2 and 2a. Since growth in weight is almost exponential (see figure 1), periodic harvests are normally distributed more or less at random in graphs with logarithmic axes. However, for the present argumentation, linear presentation is convenient, and thus most observations are found in the very beginning of the graphs. To overcome this problem to some degree, each graph has been enlarged for the lower portion to give a second figure marked a. This enlarged section is framed in the full presentation.

From figures 2 and 2a, it is evident that over the complete range of plant sizes observed, the relation between fresh and dry weight is constant. The graph is straight. Growth rates and other growth responses due to the varied conditions of propagation are not of influence on the slope or the position of the individual data between fresh and dry weight. On the 95% confidence level, all data fit the graph. Only data of midwinter grown harvests can be distinguished as a special group (dashed line), in that in winter slightly more fresh weight is formed for an amount of dry matter (6.32% versus 7.45% for the total of harvests). A further analysis of the graphs of figures 2 and 2a is given in table 1.

The data on fresh and dry weight of leaves of the same set of 82 harvests are presented in figures 3 and 3a. Again, as for shoot data, the relation between fresh and dry weight of leaves is represented by a straight line. Thus, plants from about 1 g fresh weight to plants as large as 150 g have one fixed relation between fresh and dry matter production, irrespective of growing conditions. All data fit one graph. Also the values for winter grown plants are not deviating, as they were for the total shoot data. There does not seem to be any specific influence of growing circumstances on the position of the data in the figure.
A further specification of the graph in figures 3 and 3a is given in table 2. Clearly, the slope of the function is considerably steeper for leaves than for whole shoots (0.1026 versus 0.0844).

The third relation checked from the available data is fresh weight of leaves versus shoots. These data are presented in figures 4 and 4a. Again, the function of this relation is straight. However, for each season the relation is specific. Thus, the amount of fresh leaves formed relative to fresh shoot material is dependent on the yearly cycle of greenhouse conditions. The function is steep for harvests from plants sown in April - June, it is flat for October - December sowings and the other two seasons are in between. These data are further specified in table 3.

The functions in figure 4 clearly show the phenomenon of not going through the origin of the graph. The four lines for the seasons not only have specific slopes, they also go through the Y-axis at specific distances above zero. Actually, also figures 3 and 3a show this same aspect, be it less pronounced.

It means of course, that the straight functions not quite hold all the way through to zero. For the very young stages of the seedlings the type of growth pattern evidently differs from that of plants weighing 1 - 150 g fresh.

Discussion

Earlier (de Lint and Klapwijk, 1973), most of the data used in this paper were shown as growth rate curves (see figure 1).
Plant quality differences due to growing conditions with the same data could be shown only for the amount of leaves relative to shoot. The three relations tried are properly characterized by straight lines, indicating that growth patterns are constant through the complete period of propagation, up to the stage of flowering.

When functions are linear, but do not pass through the origin, calculation of percentages should not be used. In these cases a short period of another pattern of growth in the very beginning of the seedling makes the values sensitive to plant size up to much older stages. This is demonstrated with figure 5 in which the data of figure 4 for the four lines are calculated as percentages. It will be seen that the little deviation before the plants weigh a few grams causes the values to curve down as far as to plants weighing 50-80 grams.

Whenever in an experiment plants of different fresh weights are harvested at a specific moment, it is impossible to evaluate percentage calculations as plant quality data. This can only be done when these data can be compared with data from earlier or later harvests of the same series of treatments.

Acknowledgement

We wish to thank B.J. v.d. Kaay for the calculations and Miss B. van Beek for her kind assistance throughout the investigations.

Discussion

Acock:- The relative water content of leaves (water content at harvest turgid water content) can vary from 0.6 to 0.95. Since water is 90% of the plants weight, this means that the fresh weight/dry weight ratio can vary by about 30%. It would be unwise to extrapolate your results to other situations.

De Lint:- It seems, that our data do indeed cover the same range. But the data do not allow further specification with respect to treatments.

Krizek:- In the correlation analyses that we have run on our data at Beltsville, generally fresh weight is often the most poorly correlated of all variables. While your findings are quite revealing, I am still troubled by the necessity of having to rely on a mathematical fitness of the curve instead of the actual values to determine the shape of the growth curve. If your findings are indeed valid, it would mean a considerable saving in time.

De Lint:- A relation between two data is always less accurate than one value, since it contains the errors of two observation techniques. Thus, presenting a direct observation seems acceptable. It is absolutely necessary to calculate on variability. You can indeed see what you have, but you cannot see how accurate is what you see.

Laubscher:- Wet weight, as an indication of dry weight, should be cautiously interpreted when individual instead of total leaves are considered because the osmotic potential and relative turgidity of a single leaf change during its duration of growth.

De Lint:- Still, in the data presented, young and much older plants do have the same dry matter/fresh weight relation, in spite of the shift in average leaf age.

Krug:- Your statement, that it would be sufficient to determine fresh weight, may hold true for constant conditions, but not in the field with changing weather conditions. Is that true ?

De Lint:- With sufficient successive harvests per curve you would end up with the same growth average. For growth determination as accumulated effects, fresh weight should do, also in varying conditions, but only for growth; otherwise, quality observations need a more accurate approach and on other characteristics.

Hardwick:- 1. I would like to suggest that it would be more useful, instead of plotting garphs, to calculate your data as percentages and to study whether these vary between treatments. The eye tends to oversimplify.

2. If you regard a 'band width' of 5.5 to 9.5 percent dry matter as acceptable, could you say what band width would not be acceptable ?

De Lint:- 1. We have the mathematical evaluation, it is enclosed in the manuscript. 2 No 'band width' is ideal, but the present data are the best we have been able to produce.

Newton:- Does the length of time between cutting off the plants and the determination of fresh weight influence the fresh/dry weight ratio ?

De Lint:- We cut off very few plants at a time and weigh these immediately.

References

Lint, P.J.A.L. de, and Klapwijk, D., 1973. Observations on growth and development rates of tomato seedlings. Acta Hort., 32: 161-169.

Table 1 - Mathematical specifications to the data of figures 2 and 2a.

Season		n	a	b	r
January - March	+	28	0.0874	-0.347	0.990
April - June	o	15	0.0877	-0.254	0.987
July - September	.	23	0.0781	-0.153	0.997
October - December	x	16	0.0692	-0.095	0.994
m		82	0.0844	-0.330	0.988

Table 2 - Mathematical specifications to the data of figures 3 and 3a.

Season		n	a	b	r
January - March	+	28	0.1013		0.957
April - June	o	15	0.1027		0.978
July - September	.	23	0.1039		0.992
October - December	x	16	0.0969		0.993
m		82	0.1026	-0.025	0.978

Table 3 - Mathematical specifications to the data of figures 4, 4a and 5.

a. Season		n	a	b	r
January - March	+	28	0.4289	+0.423	0.989
April - June	o	15	0.4532	+1.155	0.990
July - September	.	23	0.4097	+1.116	0.998
October - December	x	16	0.3524	+0.736	0.995
m		82	0.4210	+0.598	0.987
b. Plant size (g/plant)		n	a	b	r
0 - 10		30	0.4875		0.965
10 - 25		13	0.3560		0.866
25 - 50		11	0.5003		0.675
50		28	0.4214		0.930

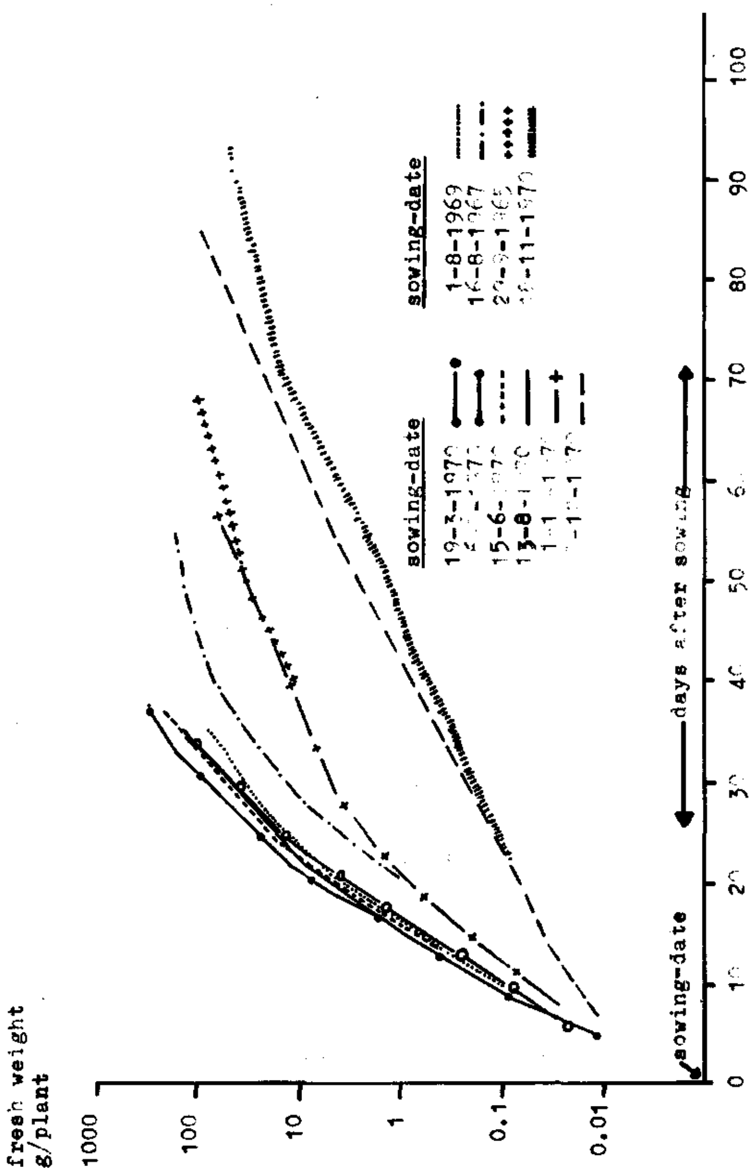

Figure 1 - Fresh weight growth of tomato seedlings (g/plant) under glass-house conditions, From P.J.A.L. de Lint and D. Klapwijk: "Observations on growth and development rates of tomato seedlings". I.S.H.S.-Symp. Naaldwijk, May 1971; Acta Hortic., in press, figure 4.

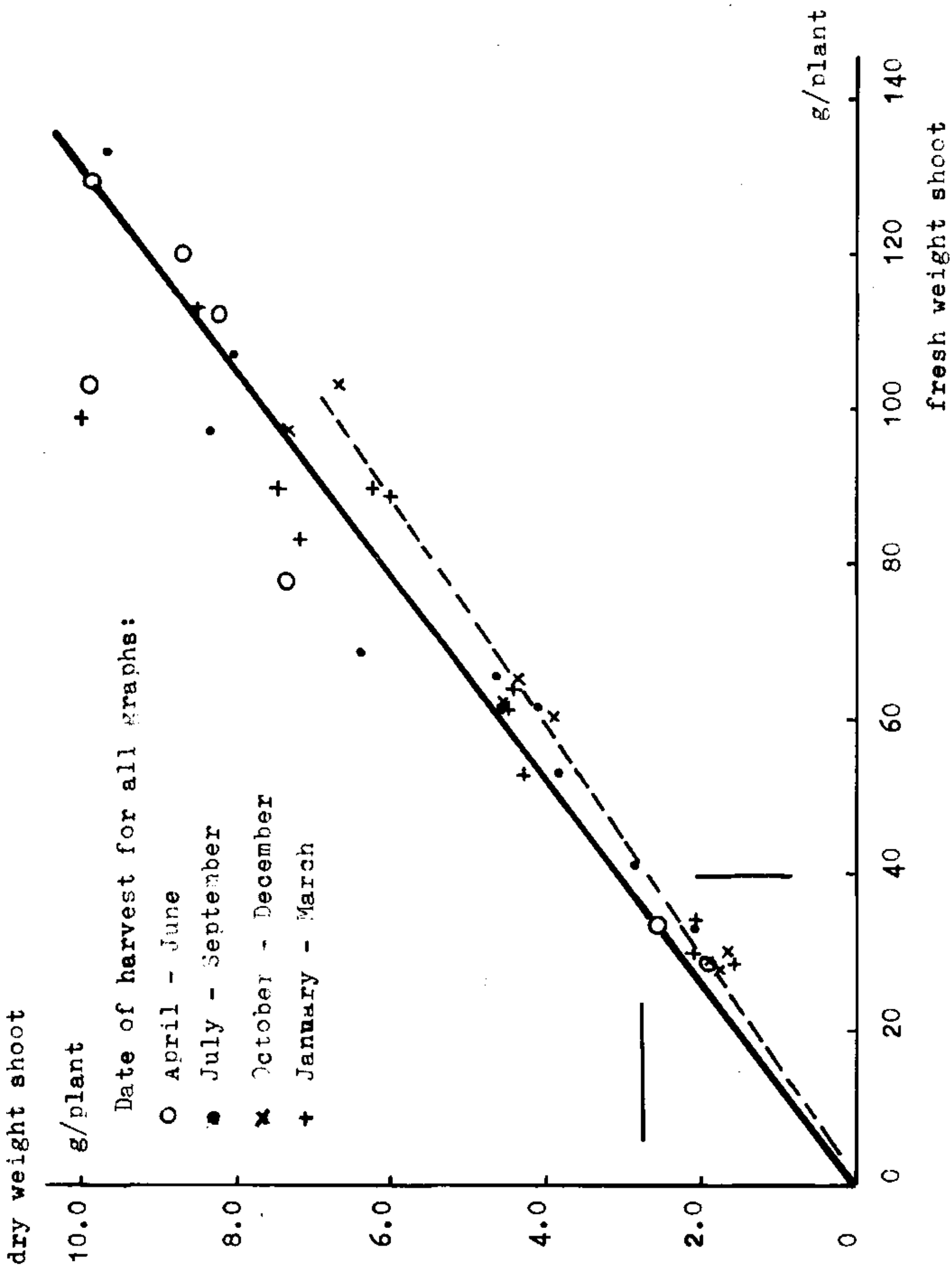

Figure 2 - Relation between dry and fresh weight of the shoots of tomato seedlings (g/plant); 82 samples.

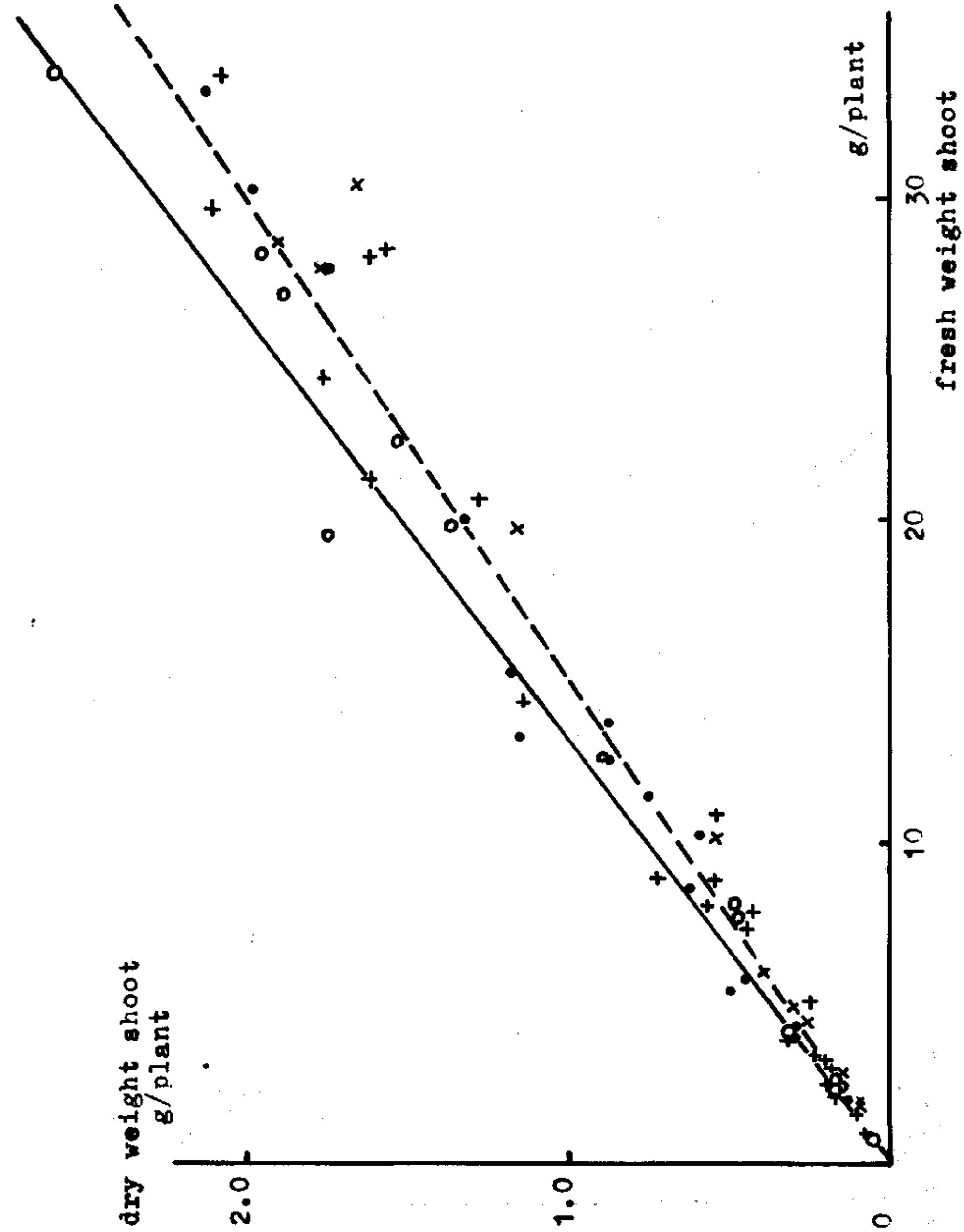

Figure 2a - Framed section of figure 2.

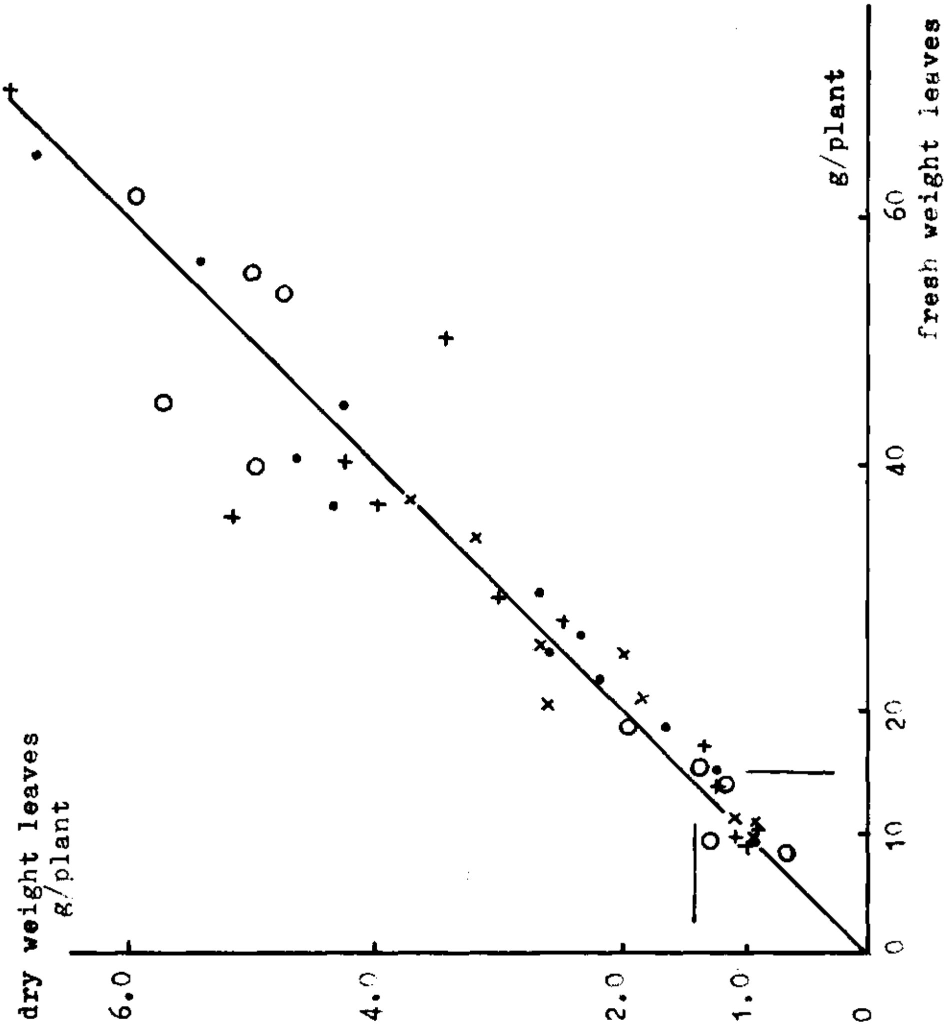

Figure 3 - Relation between dry and fresh weight of the leaves of tomato seedlings (g/plant). Same material as in figure 2.

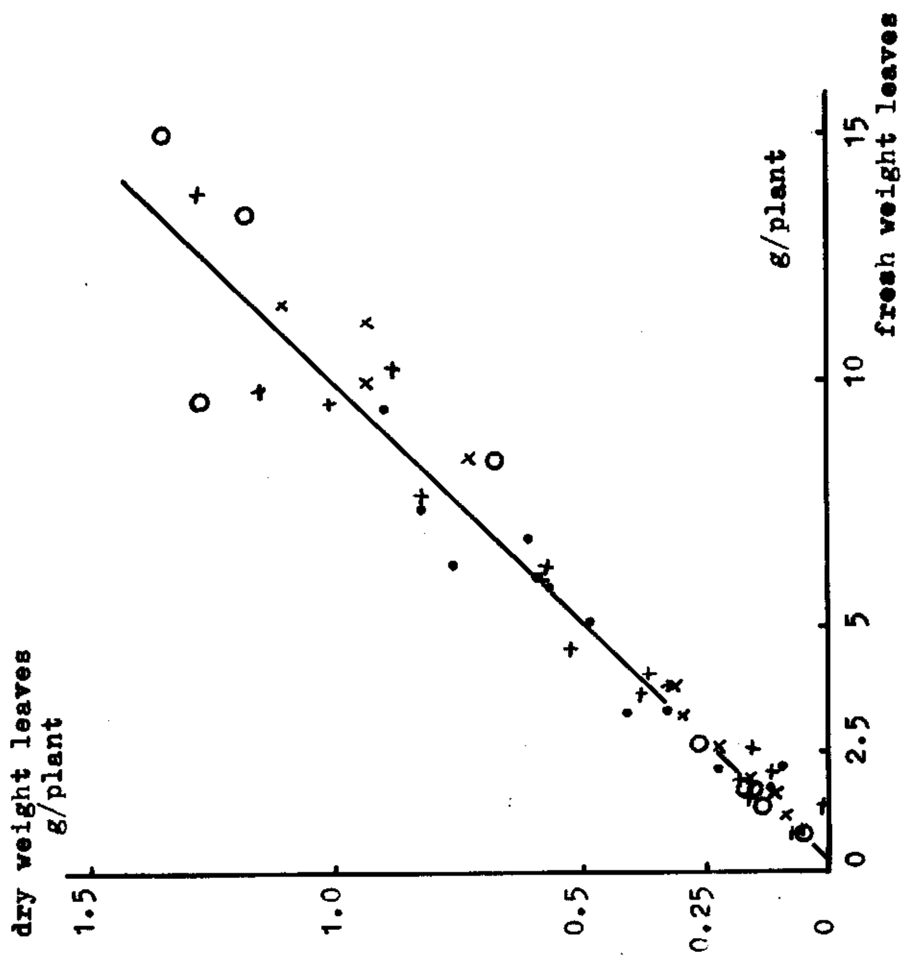

Figure 3a - Framed section of figure 3.

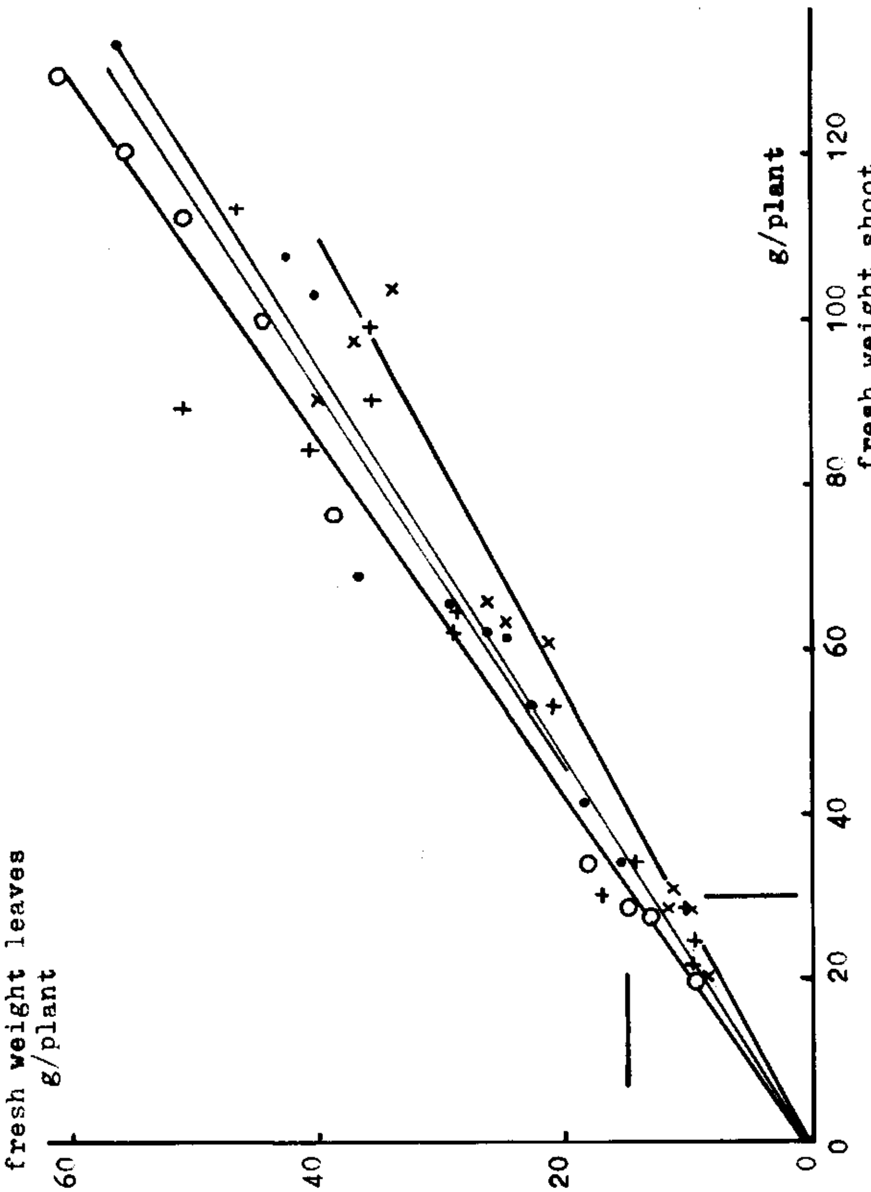

Figure 4 - Relation between fresh weights of shoot and leaves of tomato seedings. Same material as in figure 2.

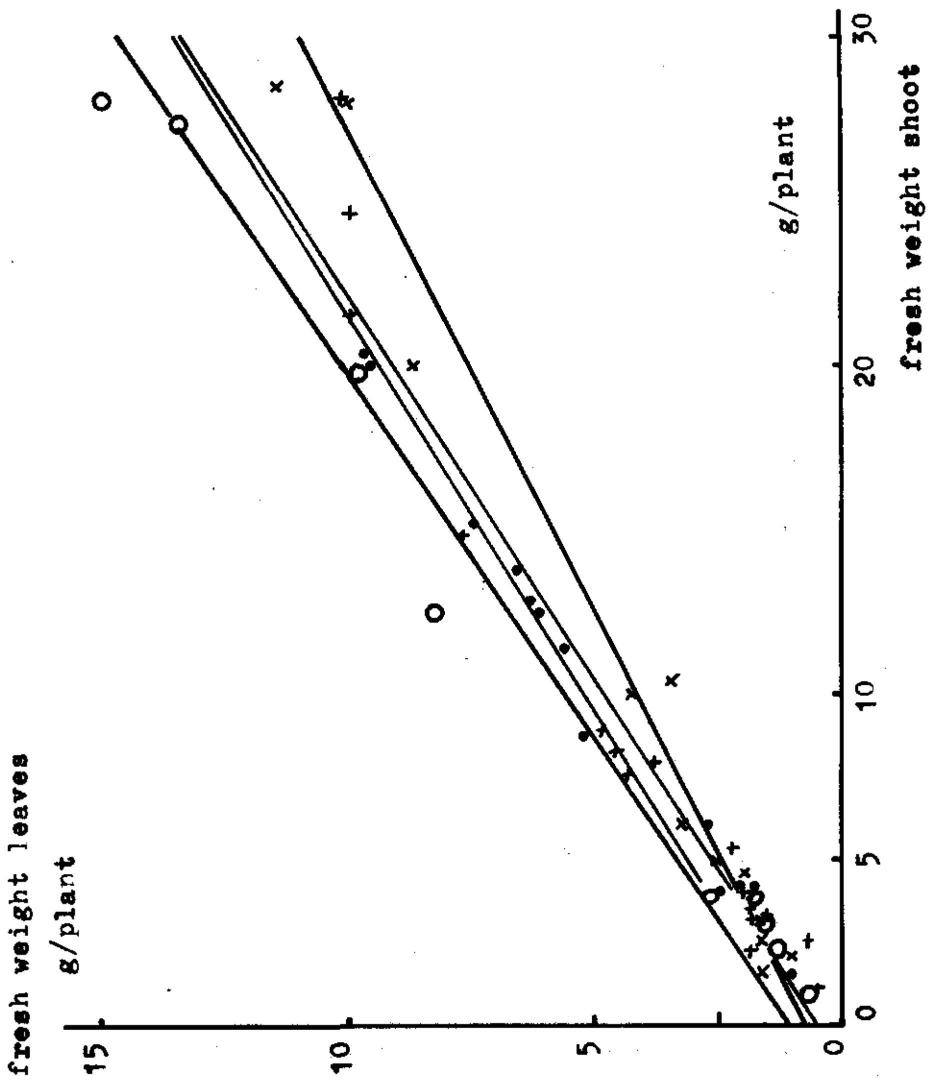

Figure 4a - Framed section of figure 4.

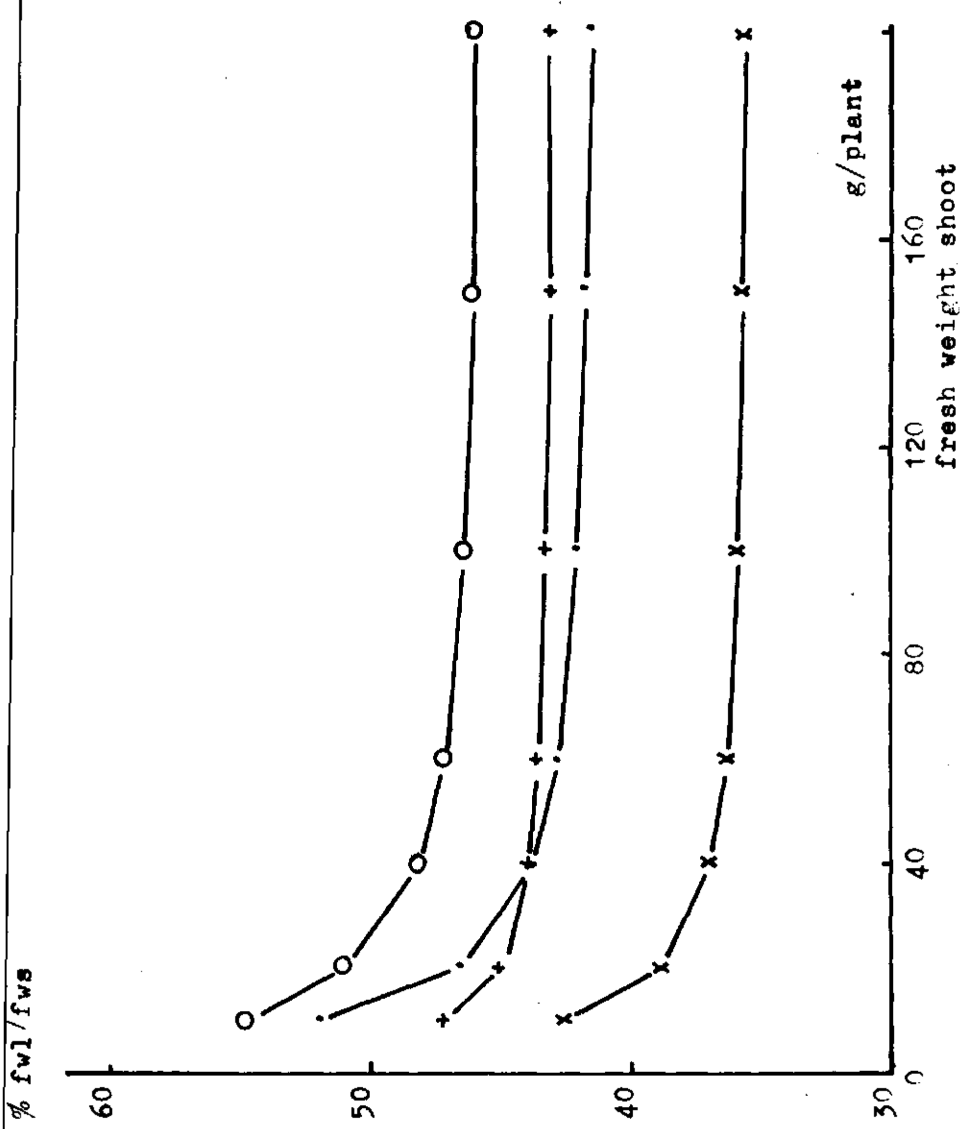

Figure 5 - Relation between percentage fresh weight leaves/shoot and fresh weight shoots of tomato seedlings. Same data as in figure 4.