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STUDIES OF GROWTH CORRELATIONS IN THE TOMATO.

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SUMMARY.

1. An investigation has been made of the correlations existing in Salads Special variety of tomato between dimensions of plant parts which can be readily measured without interfering with plant growth and dry weight of plant, area of individual leaves and fresh weight of fruit.

2. Dry weight of vegetative parts is most conveniently estimated by measuring height and diameter of stem and combining them in the function, height x *mean diameter*^{2}.

3. Leaf area may be computed by squaring the length of the mid-rib of the compound leaf, or somewhat more accurately by summing the products of lengths and widths of all leaflets.

4. Fresh weight of fruit is given reasonably closely by cube of circumference, but several other functions are also satisfactory.

5. Methods of measurement are given in detail, and tables and nomograms are presented for use in converting linear measurements into values for dry weight, area of leaf, and weight of fruit.

INTRODUCTION.

In studies of nutritional requirements, moisture relationships, and other factors governing the growth of plants, it must be realized that the yield of fruit or of vegetative material does not furnish a complete account of the effect of a treatment. It only represents an end point, and unless the development of a plant is traced progressively through its life cycle there may be no indication as to where the effect of any treatment begins, for what period it is in evidence, nor where it ends. In order to follow the history of a plant, from seed to maturity, data such as periodic measurements of the weight of the plant, the leaf area produced up to any particular time, the leaf area which still remains functional, and weights of developing fruit are required. It is often either difficult or impossible to obtain such measurements directly from the living plant, and some indirect means of assessing their magnitude is consequently desirable. The basic requirement in developing such a method is that any measurements employed are capable of being made accurately, quickly, and without the necessity of injuring growing parts of the plant

In studying growth and development in the tomato (*Lycopersicon esculentum* Mill.) it is desirable to be able to assess dry weight of plant, area of individual leaves, and fresh weight of fruit throughout the growing period. To this end, efforts were made to determine correlations between each of these factors and readily made measurements for the variety Salads Special.

REVIEW OF LITERATURE.

So far as weight is concerned, most of the published work has dealt with the assessment of the weight of a whole crop—as is done in forecasting yields of maize (Keller, 1942) and wheat (Yates, 1936)—rather than the weight of a single plant. Heath (1937), working with the cotton plant, found that a high linear correlation exists between weight and height of the plant. Stem girth has frequently been employed as an index of growth of fruit trees (Pearce, 1943; Sudds and Anthony, 1928; Tidbury, 1943), but in the available literature there is no account suggesting that the regression coefficient with weight has ever been calculated.

Many investigators have found it necessary to estimate values for leaf area by indirect means, but in most cases their methods have involved the removal of the leaves from the plant. However, Baten and Muncie (1943), using sugar beet, Young and Jeffrey (1943), tobacco, and Davis (1940), beans, found significant correlations between the product of length and width of leaves and total leaf area. Remarkable accuracy in estimating areas of leaves was obtained by Bald (1943) and Thirumalachary (1940) by comparing experimental leaves with a set of standard leaves, the areas of which had been previously measured, and their methods proved very reliable for use in the field. A number of methods has been devised for rapidly measuring the areas of compound leaves when removed from the plant, but these are of value only when it is not required to continue the life of an experimental plant. The close relationship between area and weight of tomato leaves was established by Romshe (1942), the correlation coefficient being ·9657 ± ·0064. Young and Jeffrey (1943) removed plugs of known area from tobacco leaves by means of a cork borer and calculated the area of those leaves by multiplying the weight by the ratio of area to weight in the plugs. Other investigators, such as Withrow (1935), Gerdel and Salter (1928), Kramer (1937), and Srear (1935), have employed photoelectric cells to determine the areas of irregular leaves by estimating the amount of light absorbed on placing the leaves in a beam of known intensity. In all cases, a planimeter was used as the standard instrument in finding the exact areas with which the calculated areas were compared.

In an account of a method for finding the fresh weight of fruit from measurements of other characters, Davis (1942) recorded a smooth curve where cross and suture diameters of peach fruit were plotted against fresh weight. In the majority of cases, fruit development has been represented by linear measurements such as diameter or circumference, as indices of size, but such a practice may be misleading, since growth is best considered as increase in dry weight, and weight is of cubic dimensions.

TECHNIQUE.

The material used in these investigations comprised 84 tomato plants of the variety Salads Special, transplanted into the field in April and allowed to develop during the autumn and winter months under favourable cultural conditions. All plants were pruned regularly and trained on stakes to a single stem. Groups of 12 plants were uprooted at seven different stages of development, and in the laboratory measurements were made of height of stem from point of attachment of the cotyledonary leaves to the apex of the growing tip, mean diameter of stem at the mid-point of each internode, and area of leaves remaining on the plant. A record was kept of number of leaves remaining on the plant at the time of measuring, total number of leaves produced by the plant (excluding the cotyledonary leaves), number of flowers formed, and number of fruit set. The fresh weights of leaves, stems and fruit were first determined and all parts were then dried to constant weight at 105 deg. C.

The first group of 12 plants was measured at transplanting age, the second when the first flowers were beginning to open, i.e., five weeks later; subsequent samplings were made at fortnightly intervals. The final groups contained plants carrying five, six or seven clusters of fruit or flowers, and some of the fruit had reached maturity. The plants were kept fresh during laboratory operations by placing the roots in jars of water and supporting the stems in a clamp stand. Leaves were removed for measuring one at a time, and were thus always in as fresh a condition as practicable when measured. Fruit were measured and weighed within one hour of harvesting; loss in weight and change in size during this period would be negligible.

CORRELATIONS WITH DRY WEIGHT OF PLANT.

The dry weight of vegetative parts only and the total dry weight of the plant were matched against *cube of height of stem*, *product of height and square of mean diameter of stem*, *number of leaves remaining on the plant at time of measuring*, and *total number of leaves produced at time of measuring*. Attempts were made to use other characters in various combinations. These included *volume of stem*, obtained by summing the products of length and square of diameter of all individual internodes, and *leaf area*. However, their measurement proved either too difficult or too time-consuming to be of any real practical value.

Table 1.

INTER-RELATIONSHIPS BETWEEN DRY WEIGHT OF VEGETATIVE PARTS, TOTAL DRY WEIGHT OF PLANT, AND VARIOUS PLANT CHARACTERS.

Correlated Functions.	r.	σ_e.	Regression Equation.
Dry weight of vegetative parts and *cube of height of stem*	·941	4·5872	y=·0000334x + 3·7451
Dry weight of vegetative parts and *height* x *mean diameter*^{2} *of stem*	·986	2·2871	y=·39215x — ·44602
Total dry weight and *cube of height of stem* . .	·955	6·9918	y=·00005895x + 2·5049
Total dry weight and *height* x *mean diameter*^{2} *of stem*	·934	8·4394	y=·6456x — 2·9204

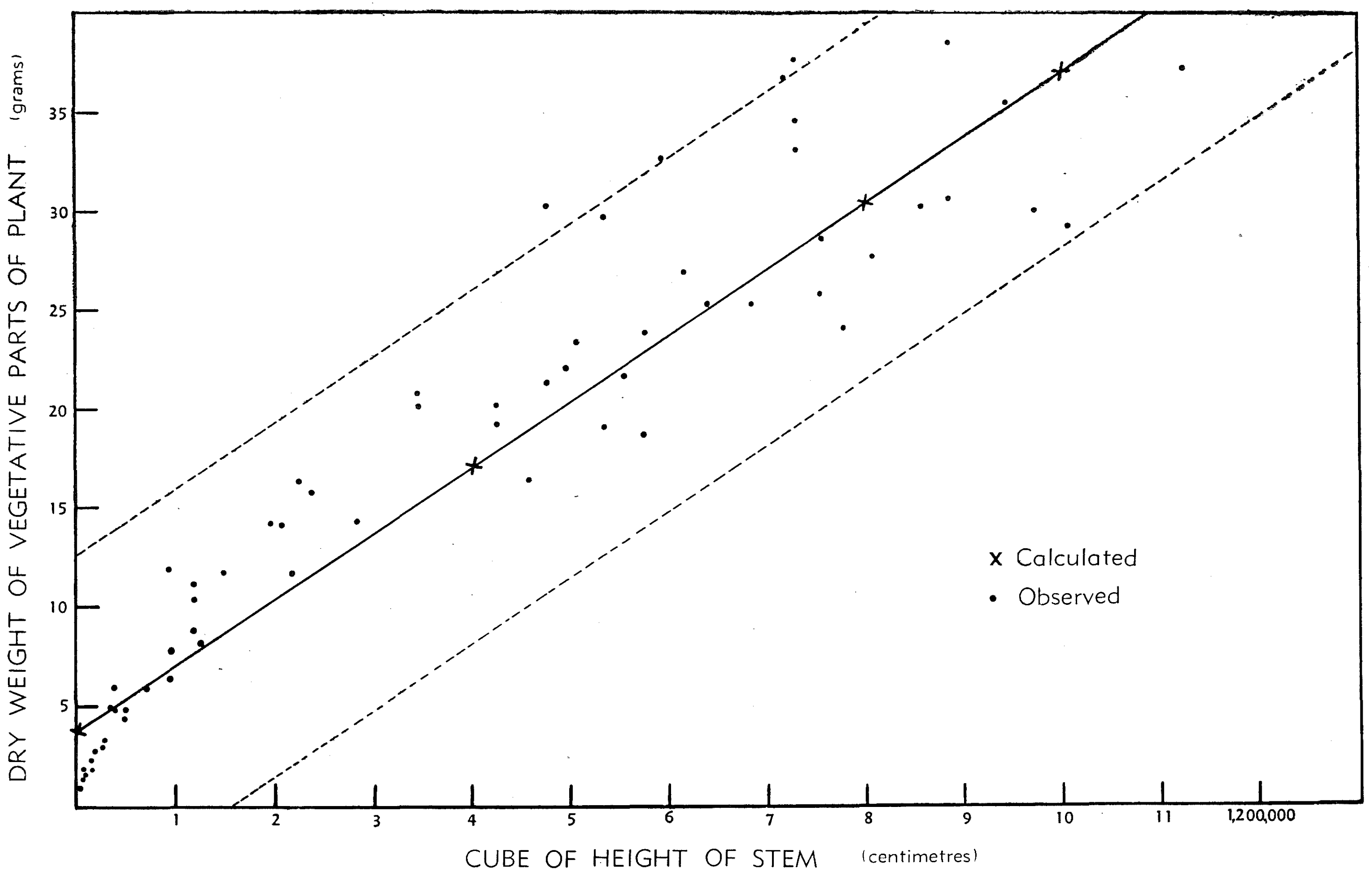

Figure 1.
Showing relationship between dry weight of vegetative parts of plant and cube of height of stem.

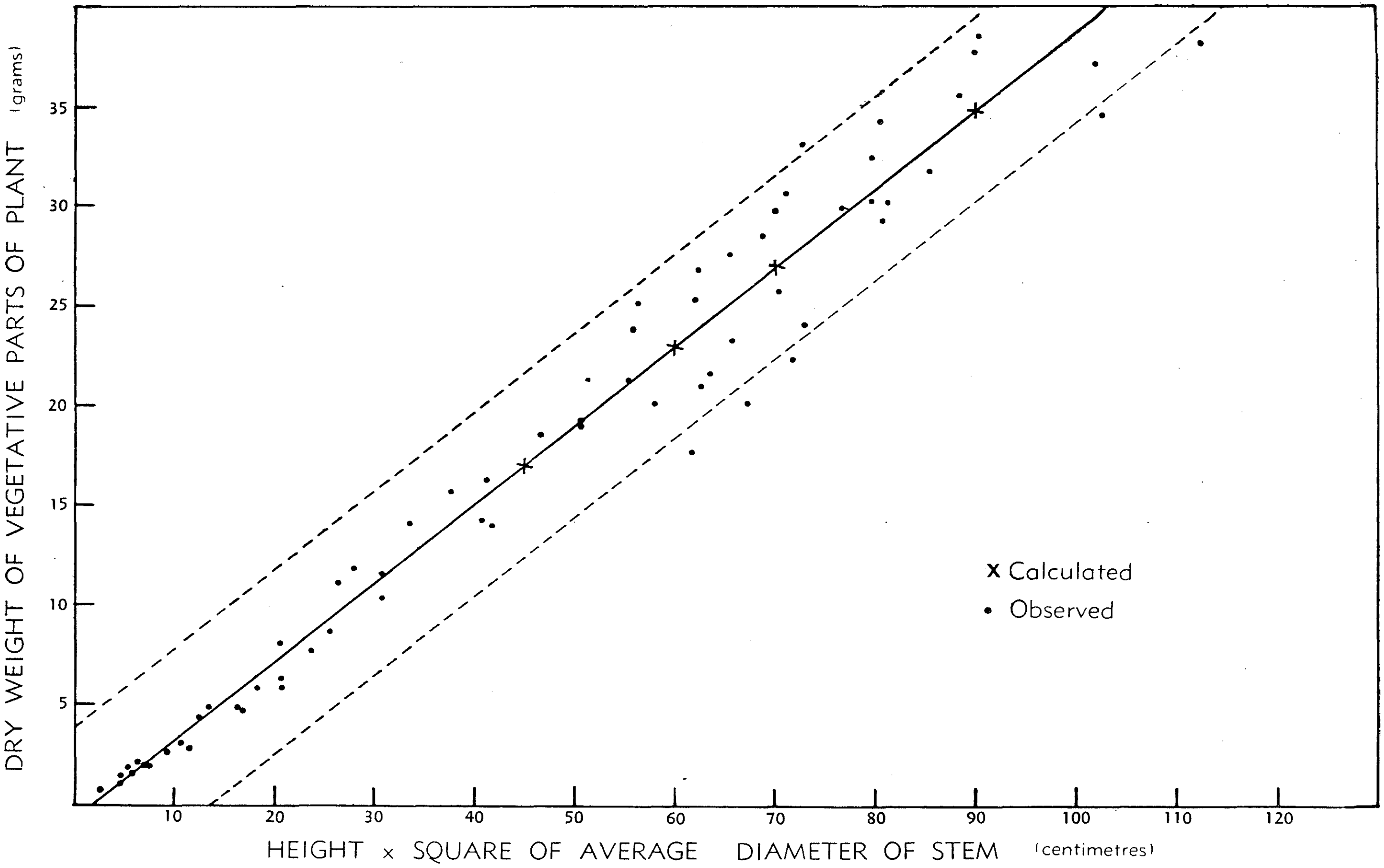

Figure 2.

Showing relationship between dry weight of vegetative parts of plant and height x square of mean diameter of stem.

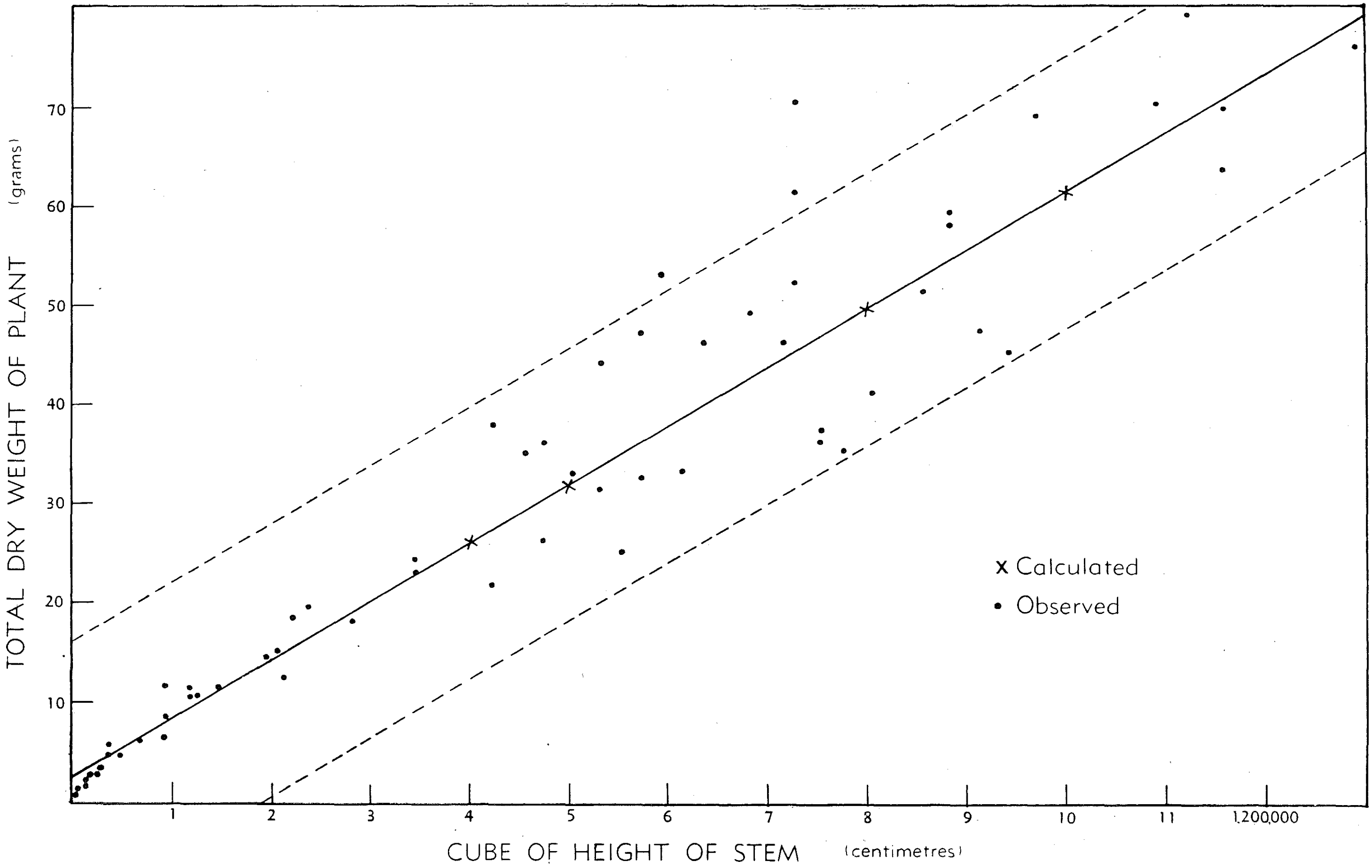

Figure 3.
Showing relationship between total dry weight of plant and cube of height of stem.

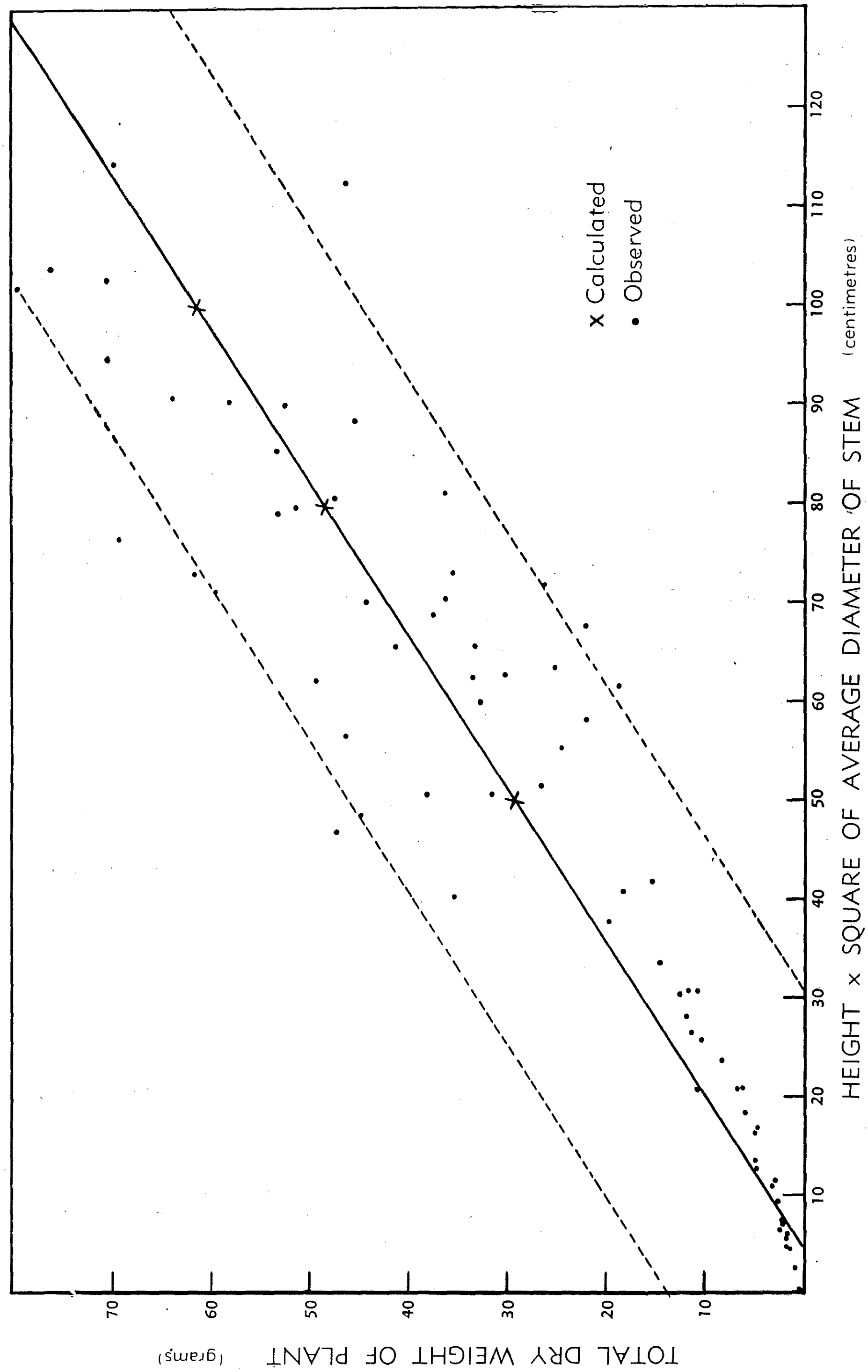

Figure 4.

Showing relationship between total dry weight of plant and height x square of mean diameter of stem.

Table 1 shows the correlation coefficient (r), the σ_e residual mean square —which is often referred to as the standard error of estimate—and the regression equation connecting dry weight with other plant dimensions. Figures 1–4 show inter-relationships of total dry weight and dry weight of vegetative parts of the plant with other functions in graphical form. The broken lines on the graphs represent limits which may be expected to include 95 per cent. of individuals of the population. They run parallel to the line to the regression equation and at a distance equal to twice σ_e from it. Hence, from Table 1, by comparison, it may be ascertained that *product of height and square of mean diameter of stem* proved to be the more reliable function from which the dry weight of the vegetative parts of the plant might be estimated.

The total dry weight of the plant showed higher values throughout for σ_e than dry weight of vegetative parts; consequently, where greater accuracy is required, it is considered that dry weight of fruit should be determined separately (see page 140) and this weight added to dry weight of the plant.

All values of r shown in Table 1 are highly significant and the accuracy sacrificed in using *cube of height of stem* in calculating dry weight of vegetative parts or total dry weight, instead of a function involving diameter of stem, will in many cases prove negligible. To enable rapid conversion of height of stem to dry weight of plant, the tables shown in Appendixes 1 and 2 have been prepared. These are convenient for use in the field, where weights can be entered directly into records by simple cross reference. It must be observed that the tables fit only the regression equations stated and it is to be expected that different equations would apply to other varieties.

Height of stem was measured from the point of attachment of the cotyledonary leaves to the axil of the youngest leaf in the growing tip. This measurement is best made by means of a flexible tape and can be carried out rapidly with an accuracy of ±0·5 cm. Study on the method of growth of the tomato showed that no more than the top 10 internodes continue to elongate at any time while the plant is growing. Consequently, in making progressive measurements of height of stem, datum points can be marked along the stem at convenient distances, provided the topmost datum point is always on or below the tenth internode from the top. Thus, on each measuring date it is necessary to measure only from the topmost datum point to the growing tip of the plant and to add the reading obtained to the value of that datum point.

When greater accuracy is desired, the compound function *height of stem* x *square of mean diameter of stem,* may be employed in calculating dry weight of vegetative parts. A nomogram (Figure 5) has been prepared to provide a means of rapid conversion. In this case, the c term of the equation ($y = mx + c$) is disregarded, as it is of small magnitude (less than σ_e) and will not greatly influence the result obtained. Mean diameter of the stem was obtained by averaging the diameters of all internodes measured at approximately the mid-point of each, in a plane at right angles to that containing the petiole of the leaf at the lower node. The measurements were made with slide calipers, which proved a very satisfactory instrument for the purpose.

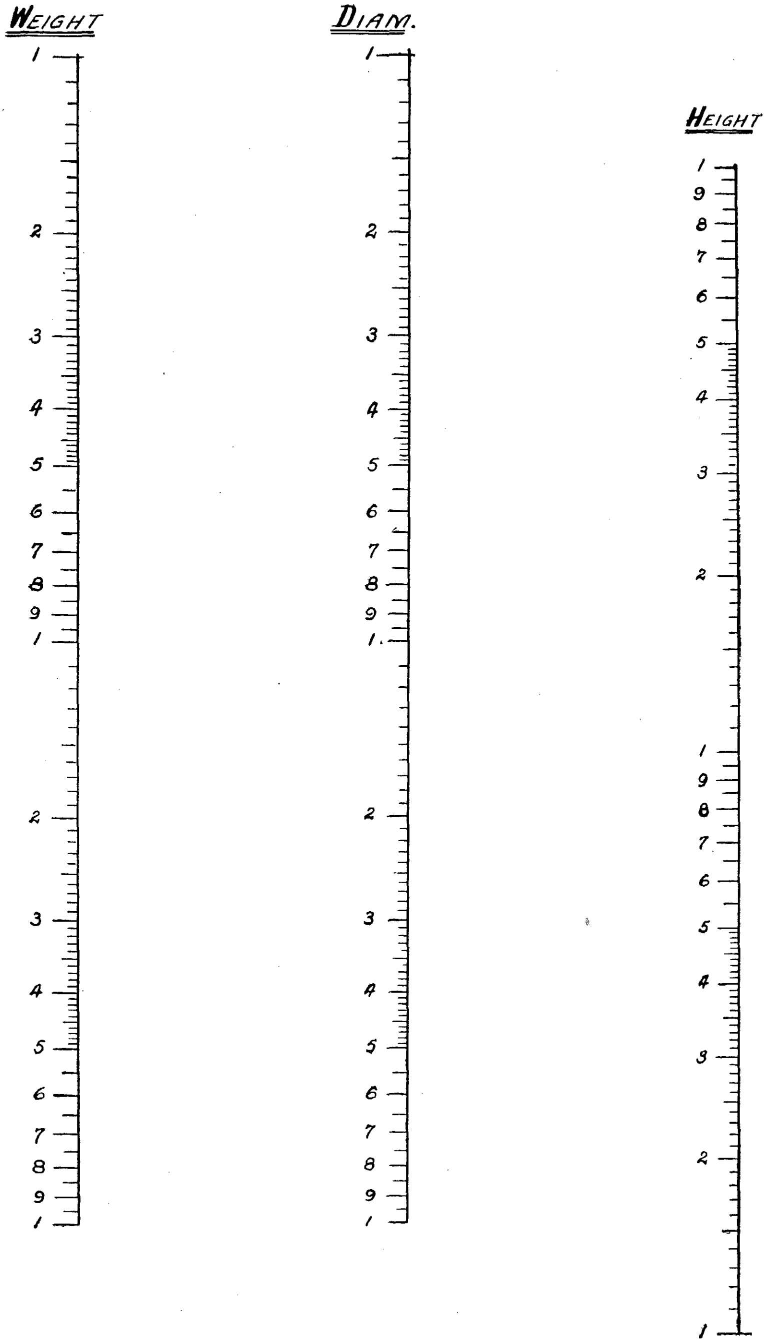

Figure 5.

Nomogram connecting Total Dry Weight of Plant (in grams) with Height (in cms.) and Mean Diameter of Stem (in cms.), according to the Equation: Total Dry Weight = 0·6456 Ht. x Mean Diam.^{2}

Table 2.

RELATION BETWEEN TOTAL NUMBER OF LEAVES PRODUCED AT TIME OF MEASURING AND DRY WEIGHT OF VEGETATIVE PARTS OF PLANT.

Number of Leaves Produced.	Dry Weight of Vegetative Parts of Plant (gms.)	Mean.
4	·12, ·15, ·16, ·16	·1475
5	·13, ·19, ·13, ·15, ·20, ·17, ·15, ·14	·1575
9	1·21	1·21
10	1·48	1·48
11	2·1, 2·65	2·375
12	2·03, 2·9, 2·07, 1·65	2·1625
13	4·9, 3·11, 4·96	4·3233
14	4·8	4·8
15	6·11, 5·94	6·025
16	8·82, 21·73	15·275
18	10·49, 7·82, 14·05, 11·56, 4·36, 11·1, 6·48	9·4086
19	17·8, 14·38, 11·91, 21·71, 14·15	15·99
20	20·22, 23·4, 8·07	17·23
21	20·11, 25·97, 21·33, 11·67, 15·85, 28·62	20·5917
22	22·46, 21·3, 30·36, 19·18	23·325
23	23·92, 22·1, 19·04, 26·99	23·0125
24	36·87, 24·05, 29·33, 30·69	30·235
25	39·79, 30·3, 34·39, 27·58, 16·43	29·698
26	30·00, 38·64, 35·54, 25·21	32·3475
27	32·52, 40·96, 18·60	30·6933
28	41·82, 33·16, 25·33	33·4367
29	48·92, 37·39	43·155
30	34·61	34·61

Table 3.

RELATION BETWEEN NUMBER OF LEAVES REMAINING ON PLANT AT TIME OF MEASURING AND DRY WEIGHT OF VEGETATIVE PARTS OF PLANT.

Number of Leaves Remaining.	Dry Weight of Vegetative Parts of Plant (gms).	Mean.
3	·12	·12
4	·15, ·16	·155
5	·13, ·19, ·13, ·15, ·20, ·17, ·16, ·15, ·14	·158
7	1·21	1·21
9	1·48, 2·65, 1·65	1·927
10	2·10, 2·03, 2·90, ·78	1·952
12	4·80, 4·90, 3·11, 2·07, 4·96, 6·48	4·387
13	5·90, 11·67, 21·73, 14·15, 8·07	12·304
14	1·71, 14·05, 21·71, 8·82, 4·36, 11·10, 21·30	11·864
15	5·90, 17·80, 11·91, 19·04, 29·33, 19·18	17·193
16	7·82, 20·22, 25·97, 23·40, 28·62	21·206
17	10·49, 20·11, 15·56, 14·38, 23·92, 22·10, 15·8	17·487
18	22·46, 21·33, 24·05, 35·54, 33·16, 16·43	25·495
19	30·30, 30·36, 34·39, 18·60, 27·58, 25·33	28·178
20	36·87, 39·79, 26·99, 30·00, 38·64	34·458
21	40·96, 34·61, 25·21	33·593
22	32·52, 41·82, 37·39	37·243
24	48·92	48·92
31	31·97, 29·79	30·880

Neither *number of leaves remaining on plant* nor *total number of leaves produced at time of measuring* provided a sufficiently reliable means of estimating the dry weight of plant. Tables 2 and 3 show an increase in mean dry weight accompanying an increase in number of leaves, but it will be seen that the variation within the individual dry weights contributing to the mean is so large that the number of leaves cannot be taken as a reliable measure of the amount of growth made by any one plant. Hence, these numbers cannot be regarded as a satisfactory source from which to estimate dry weight of plant.

CORRELATIONS WITH LEAF AREA.

The functions employed to ascertain a means of computing leaf area were *square of length of mid-rib of compound leaf* (L^2); *product of length of mid-rib* (L) *and sum of lengths of leaflets* (Σl), i.e., $L \times \Sigma l$; and *sum of products of lengths and widths of all leaflets* ($\Sigma (l \times w)$).

Table 4.

INTER-RELATIONSHIPS BETWEEN AREAS AND LINEAR MEASUREMENTS OF INDIVIDUAL COMPOUND LEAVES.

Factors Correlated with Leaf Area.	r.	σ_e.	Regression Equation.
Square of length of midrib (L^2)	·9589	37·9987	$y = \cdot 29109\,x - 6\cdot 8006$
Product of length of mid-rib and sum of lengths of leaflets ($L \times \Sigma\, l$)	·9791	19·6443	$y = \cdot 08540\,x + 8\cdot 89572$
Sum of products of lengths and widths of leaflets $\Sigma\,(l \times w)$	·9919	12·2668	$y = \cdot 61225\,x + 3\cdot 66132$

Table 4 shows the correlation coefficient (r), the σ_e residual mean square and the regression equations connecting the total area of the compound leaf with different combinations of linear dimensions. Examination of the values of r and σ_e indicates that the function $\Sigma\,(l \times w)$ offers the most accurate means of indirectly estimating the leaf area, but the necessary measurements involve so much slow and delicate work that only a small number of leaves can be measured each day. The suitability of the function ($L \times \Sigma l$) lies intermediate between that of the functions $\Sigma\,(l \times w)$ and L^2, both as regards accuracy of estimate and ease of measurement, and since its accuracy is not much greater than that of the function L^2 the latter is used in preference to it. Where the highest degree of accuracy is desired the function $\Sigma\,(l \times w)$ should be used.

The results obtained in this section of the work are plotted graphically in Figures 6-8. The values of σ_e again provide a reliable index of the scatter of the points, and thereby afford a measure of the degree of accuracy of the estimate. The broken lines on the graphs are drawn at a distance equal to twice σ_e on each side of the regression line and are to be expected to contain 95 per cent. of the population. A nomogram connecting leaf area with overall length and sum of lengths of leaflets is given as Figure 9.

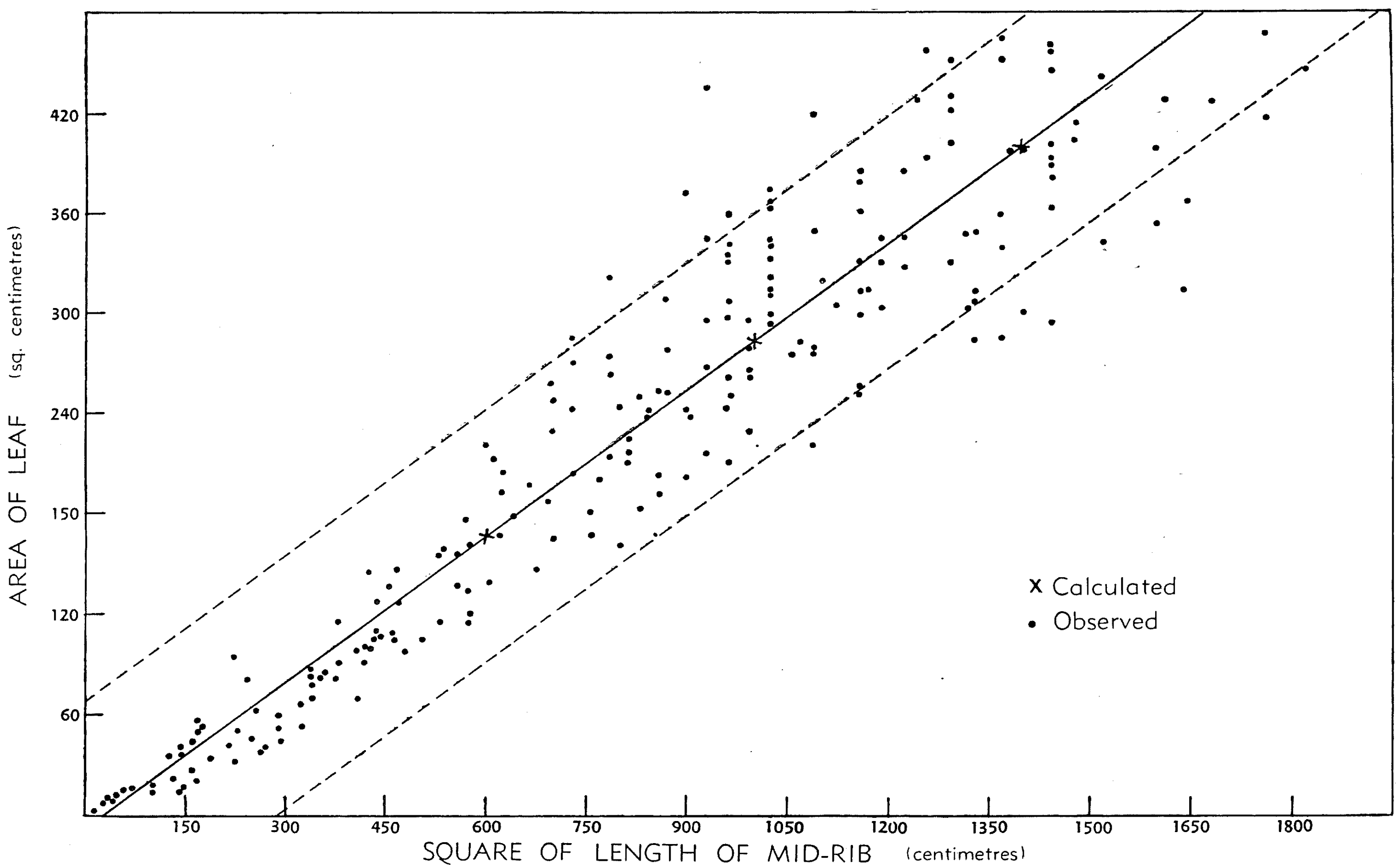

Figure 6.

Showing relationship between area of leaf and square of length of mid-rib.

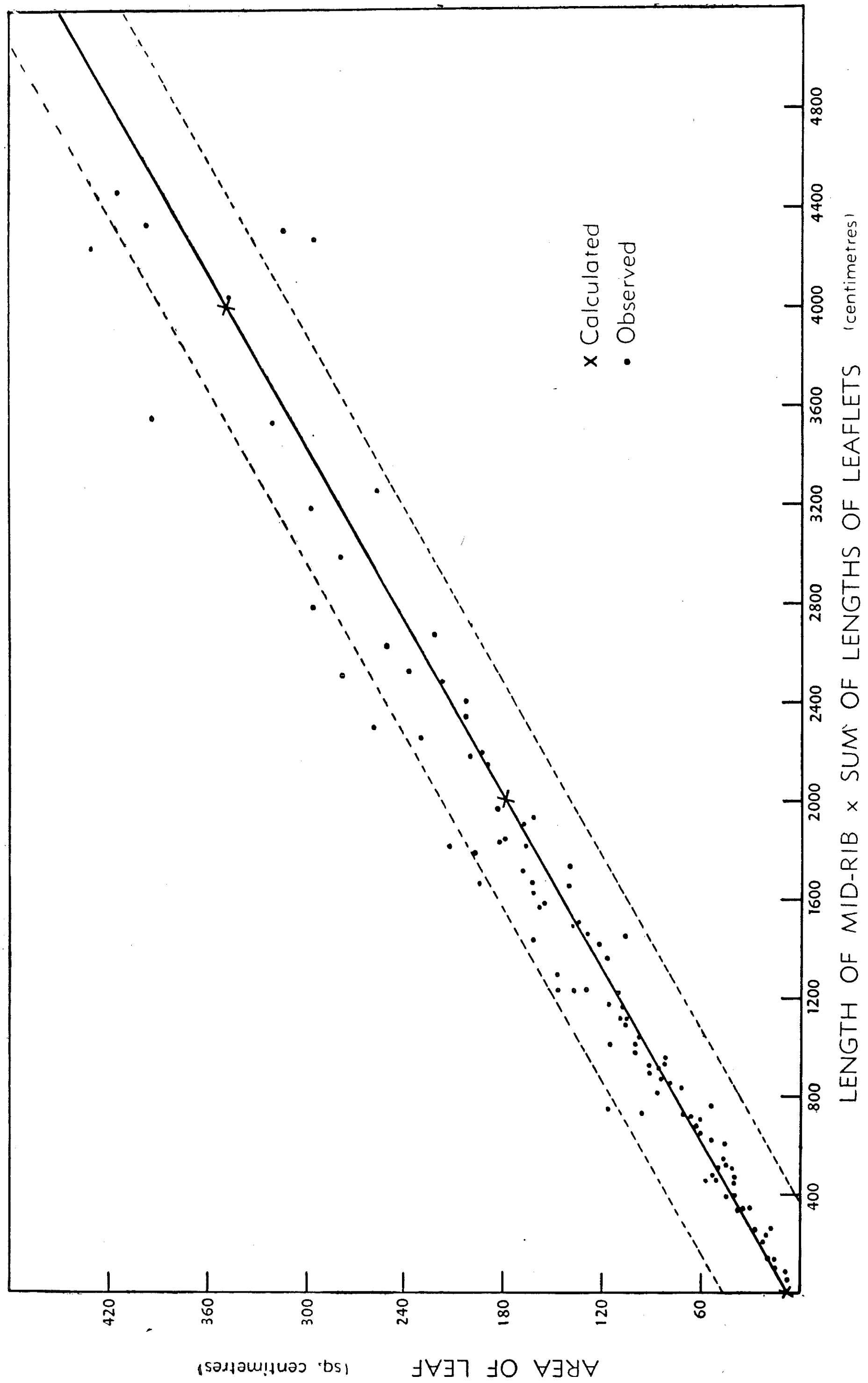

Figure 7.

Showing relationship between area of leaf and length of mid-rib x sum of lengths of leaflets.

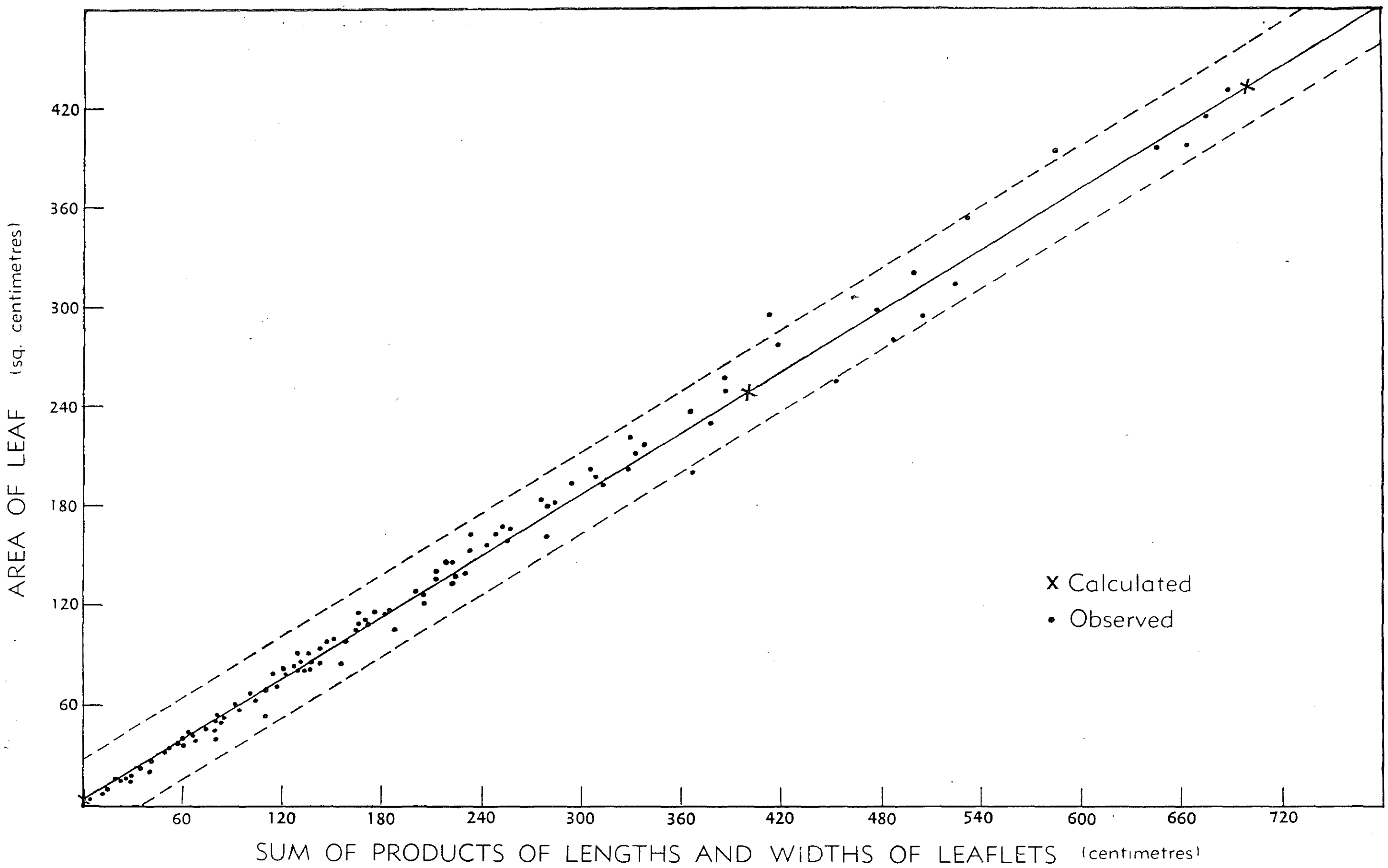

Figure 8.

Showing relationship between area of leaf and sum of products of lengths and widths of leaflets.

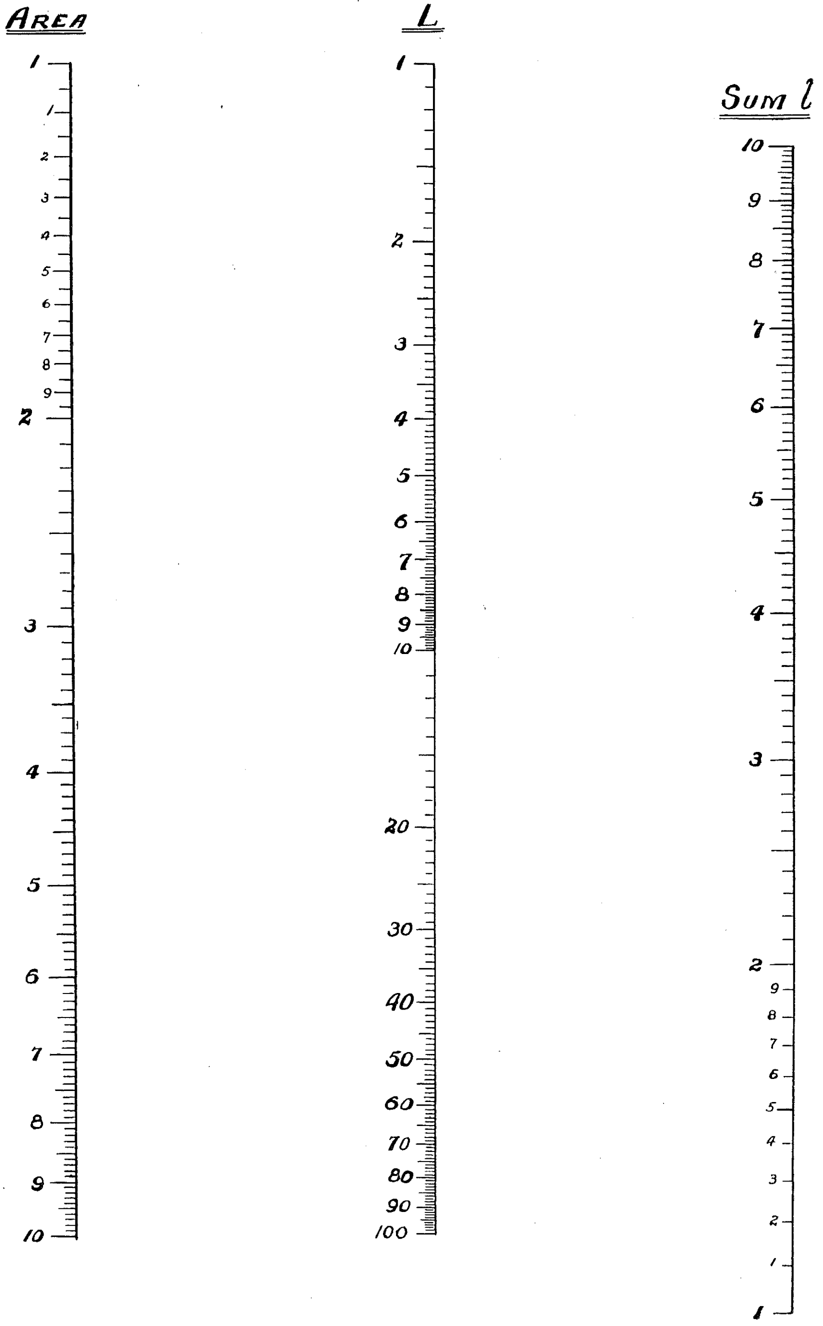

Figure 9.

Nomogram connecting Area of a Compound Leaf (in sq. cms.) with its Overall Length, L (in cms.) and Sum of Lengths of Leaflets, $\sum l$, (in cms), according to the equation: Area = $0{\cdot}08540 \sum l \times L$.

Working with compound leaves of beans, Davies (1940) found a close relationship to exist between total area of the compound leaf and product of length and width of the terminal leaflet. Table 5 demonstrates that the dimensions of the terminal leaflet taken separately or in any combination do not bear any relation to the area of the compound leaf in the Salads Special

Table 5.

RELATION BETWEEN TOTAL AREAS OF COMPOUND LEAVES AND THE DIMENSIONS OF THEIR TERMINAL LEAFLETS.

Length of Terminal Leaflet (l).	Width of Terminal Leaflet (w).	l x w.	Area of Terminal Leaflet.	Area of Compound Leaf.
Cm.	Cm.	Sq, Cm.	Sq. Cm.	Sq. Cm.
1·75	0·75	1·3	0·75	2·3
4·0	2·0	8·0	4·75	13·8
3·25	2·5	8·1	5·0	33·9
4·0	3·0	12·0	5·0	40·7
4·5	2·5	11·25	7·5	51·3
6·0	3·0	18·0	10·5	60·3
5·5	3·0	16·5	9·0	66·75
4·5	2·25	10·1	5·75	73·9
5·5	3·0	16·5	9·25	79·4
6·5	3·5	22·8	13·0	81·8
6·75	4·0	27·0	13·75	91·9
4·0	3·0	12·0	8·0	102·3
5·0	2·5	12·5	6·25	109·9
5·75	3·0	17·25	11·0	110·25
5·0	2·25	11·25	6·75	121·3
6·0	3·0	18·0	11·0	126·8
5·5	2·75	15·1	9·0	128·6
5·0	3·0	15·0	7·75	137·9
3·25	2·75	8·9	5·5	142·8
6·0	3·25	19·5	12·0	156·8
7·25	3·5	25·4	14·5	165·6
4·5	2·5	11·25	8·0	176·3
6·5	3·0	19·5	10·5	181·2
8·5	4·0	34·0	19·0	204·1
5·5	3·75	20·6	10·75	211·1
6·5	3·0	19·5	12·0	222·1
8·0	4·0	32·0	18·5	232·0
6·75	3·5	23·6	14·25	233·2
7·25	3·5	25·4	16·0	245·9
8·5	4·0	34·0	21·75	257·4
8·25	4·25	35·06	21·5	276·6
6·25	4·0	25·0	16·0	283·2
6·0	4·0	24·0	15·0	294·3
8·5	4·25	36·1	21·75	305·6
9·0	4·25	38·25	21·25	328·9
6·5	5·0	32·5	16·5	332·9
7·0	3·5	24·5	14·0	366·5
9·0	4·0	36·0	21·25	377·9
7·5	4·0	30·0	18·5	384·0

variety of tomato. It has also been observed with many other varieties of tomato that the terminal leaflets of the compound leaves do not conform to any fixed shape, neither do their dimensions bear any relation to the area of the compound leaf. Hence, a similar connexion to that found for beans apparently does not exist in the case of the tomato.

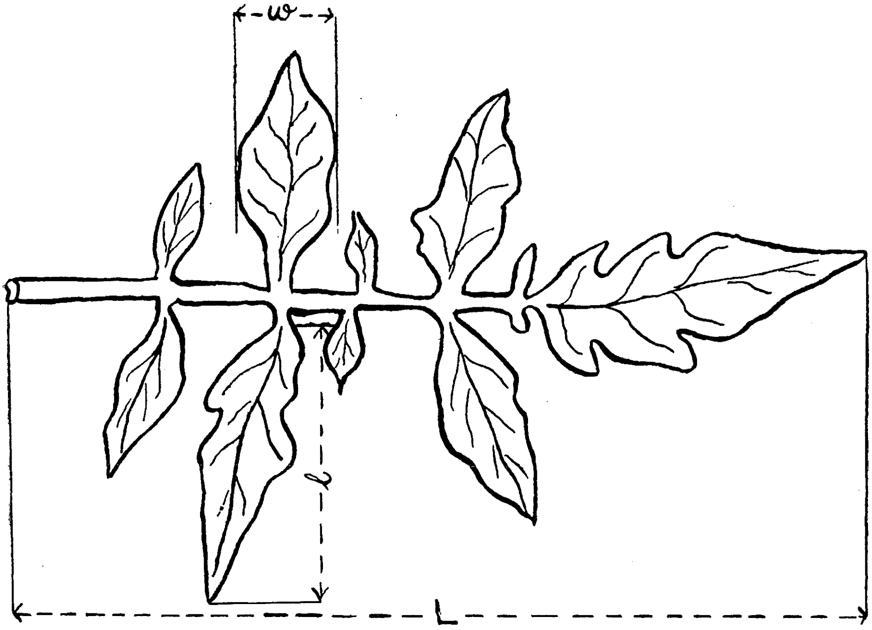

Figure 10.

Showing limits between which measurements of length of mid-rib (L), length of leaflet (l) and width of leaflet (w) are made.

The limit points chosen in making the measurements connected with leaf area are demonstrated in Figure 10. The length of the mid-rib (*L*) can be very rapidly measured by means of a light rigid scale. A stiff steel tape proved the most convenient instrument for this purpose. The leaflets are difficult to measure, mainly on account of the large number per leaf and their irregular outline. Consequently, the number of leaves which can be measured on each occasion is strictly limited when the dimensions of all leaflets are to be recorded.

At one stage in these studies a planimeter was used as the standard instrument in determining leaf area. However, a method was devised whereby the leaves were superimposed upon squared paper glued to heavy cardboard. A check of the differences between the areas measured by this means and those measured by the planimeter showed the maximum difference to be 5·2 per cent., as shown in Table 6, and the standard deviation of the percentage differences was 0·47, which for the purpose of this work is considered a satisfactory experimental error. In addition, it was found that the time taken to measure a leaf by means of the planimeter was almost twice as long as that taken to measure the same leaf by the squared paper method; further, experience in the use of the latter method tended to improve the accuracy and also to increase the speed of measurement.

Table 6.

DIFFERENCES BETWEEN AREAS MEASURED BY MEANS OF SQUARED PAPER AND BY MEANS OF A PLANIMETER.

Area by Squared Paper.	Area by Planimeter.	Difference.	Percentage Difference.
42·0	40·0	2·0	5·0
69·0	66·4	2·6	3·9
105·0	104·2	0·8	0·7
132·0	128·4	3·6	2·8
188·0	185·0	3·0	1·6
190·0	185·0	5·0	2·7
202·0	203·0	−1·0	−0·5
206·0	197·0	9·0	4·6
228·0	230·5	−2·5	−1·1
333·5	317·0	16·5	5·2
348·0	337·7	10·3	3·3
357·8	350·5	7·3	2·1
359·0	357·2	1·8	0·5
387·0	390·0	−3·0	−0·8
402·0	393·0	9·0	2·3
432·0	444·0	−12·0	−2·7
457·5	454·2	3·3	0·7
476·0	456·0	20·0	4·4
490·0	503·0	−13·0	−2·6
545·0	546·0	−1·0	−0·2
581·0	560·0	21·0	3·8
611·8	596·0	15·8	2·7
655·0	633·0	22·0	3·5
676·0	651·0	25·0	3·8
704·8	686·0	18·8	2·7

Area was measured in square centimetres, and the board was ruled into squares of ¼ sq. cm. area. To assist in counting the lines were ruled in various colours, a regular arrangement being adopted whereby the same colour appeared at each fifth centimetre along both axes, as shown in Figure 11. The surface of the board was waxed to avoid staining with the pigments of the leaves, thereby prolonging its life.

Measuring was done in the laboratory, where the leaves were removed from the plants one at a time. The leaflets were detached and spread out over the surface of the squared board so as to leave as little uncovered area as possible. They were then covered with glass to prevent curling at the edges. The uncovered squares were counted and their number subtracted from the total number of squares within the rectangle containing all the leaflets. The resulting number divided by four gave the area of the leaf in square centimetres.

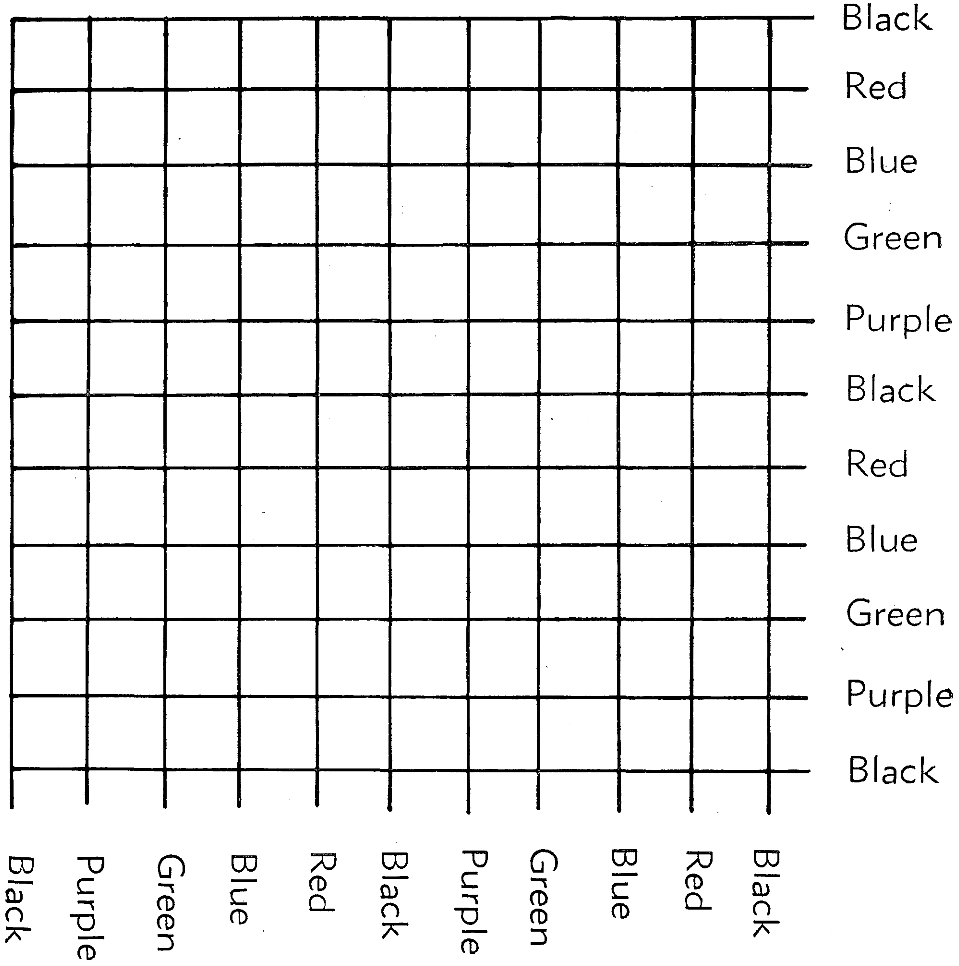

Figure 11.

Showing the arrangement of coloured lines on a section of the board used in measuring leaf area.

CORRELATIONS WITH FRESH WEIGHT OF FRUIT.

Equatorial circumference, greatest equatorial diameter, and depth of fruit were correlated with fresh weight of fruit, separately and in all combinations. Weight was regarded as a cubical function, and consequently combinations of three factors were selected as those expected to give the closest correlations.

Fresh weight of fruit was employed throughout this section of the work, as the drying of the fruit was cumbersome and costly and consumed a great amount of time. It was found in the course of these studies, however, that the percentage of water contained in fruit of even greatly different ages very closely approached a constant value. The mean percentage of water contained in 60 fruit in various stages of maturity was found to be 92·3, and the standard deviation for this population was 1·26. It was considered, then, that as an index of growth the fresh weight was sufficiently reliable, and where required dry weight could be taken as 7·7 per cent. of the fresh weight.

Throughout these studies the fruit was weighed and measured immediately on removal from the plant so that no appreciable loss occurred through evaporation. All fruit was weighed with the stem button removed. Equatorial circumference was measured with a narrow flexible steel tape, and this operation after a little practice could be performed rapidly to an accuracy of ±0·5 millimetres. In practice, the circumference is the dimension most easily measured, and the matter of deciding which is the greatest diameter and the most suitable position at which to measure the depth is avoided when it is used. By means of a narrow flexible steel tape—or better, by means of a circumeter as described by Morris (1939)—this measurement can be easily obtained in the field while the fruit is still on the plant.

Greatest equatorial diameter was measured with slide calipers, which were difficult to manipulate on the larger fruit. Several positions required to be measured in order to determine the greatest diameter, thereby consuming extra time. Depth was measured from the shoulder of the fruit to the lowest point at the stylar end. Slide calipers were used, and the same difficulties were encountered as in measuring the diameter.

All values of r obtained in this section of the work were very highly significant, and the values of σ_e were very low, as is shown in Table 7. Graphical interpretation of these results, shown in Figures 12-19, confirms the evidence in

Table 7.

INTER-RELATIONSHIPS BETWEEN FRESH WEIGHT OF FRUIT AND EXTERNAL LINEAR DIMENSIONS.

Functions Correlated with Fresh Weight of Fruit.	r.	σ_e.	Regression Equation.
Cube of Diameter	·9884	2·5899	y = ·43827 x +·51226
Cube of Depth	·9730	3·9309	y = ·83479 x − ·45521
Cube of Circumference	·9947	1·7515	y = ·01540 x + ·17964
Diameter^2 x Depth	·9977	1·14646	y = ·56213 x −·39111
Circumference^2 x Depth	·9988	·8357	y = ·05985 x −·48749
Diameter x Depth^2	·9924	2·10014	y = ·69658 x −·71548
Circumference x Depth^2	·9915	2·2221	y = ·22653 x −·70414
Diameter x Depth x Circumference	·9986	·89903	y = ·18356 x −·45124

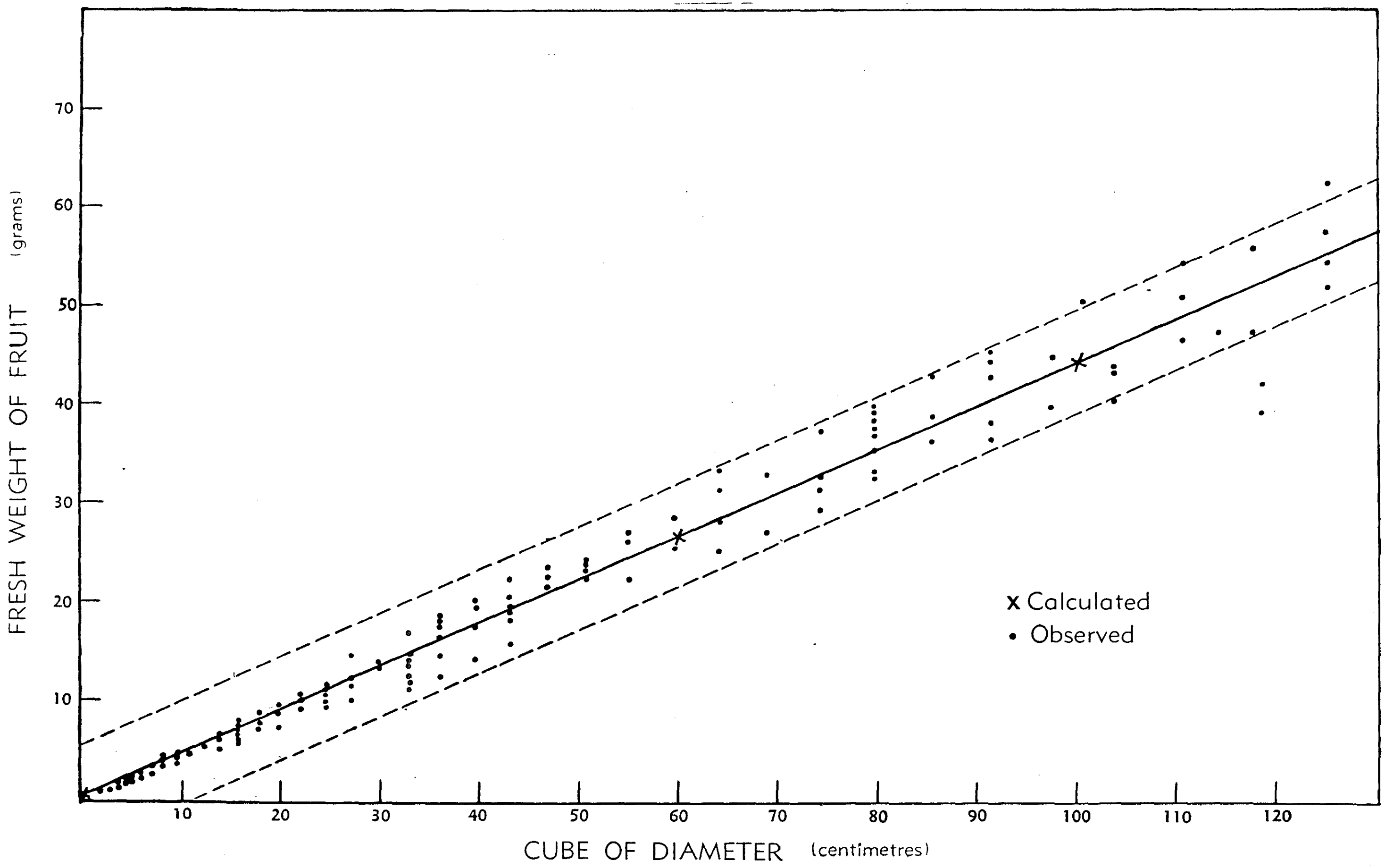

Figure 12.
Showing relationship between fresh weight of fruit and cube of diameter of fruit.

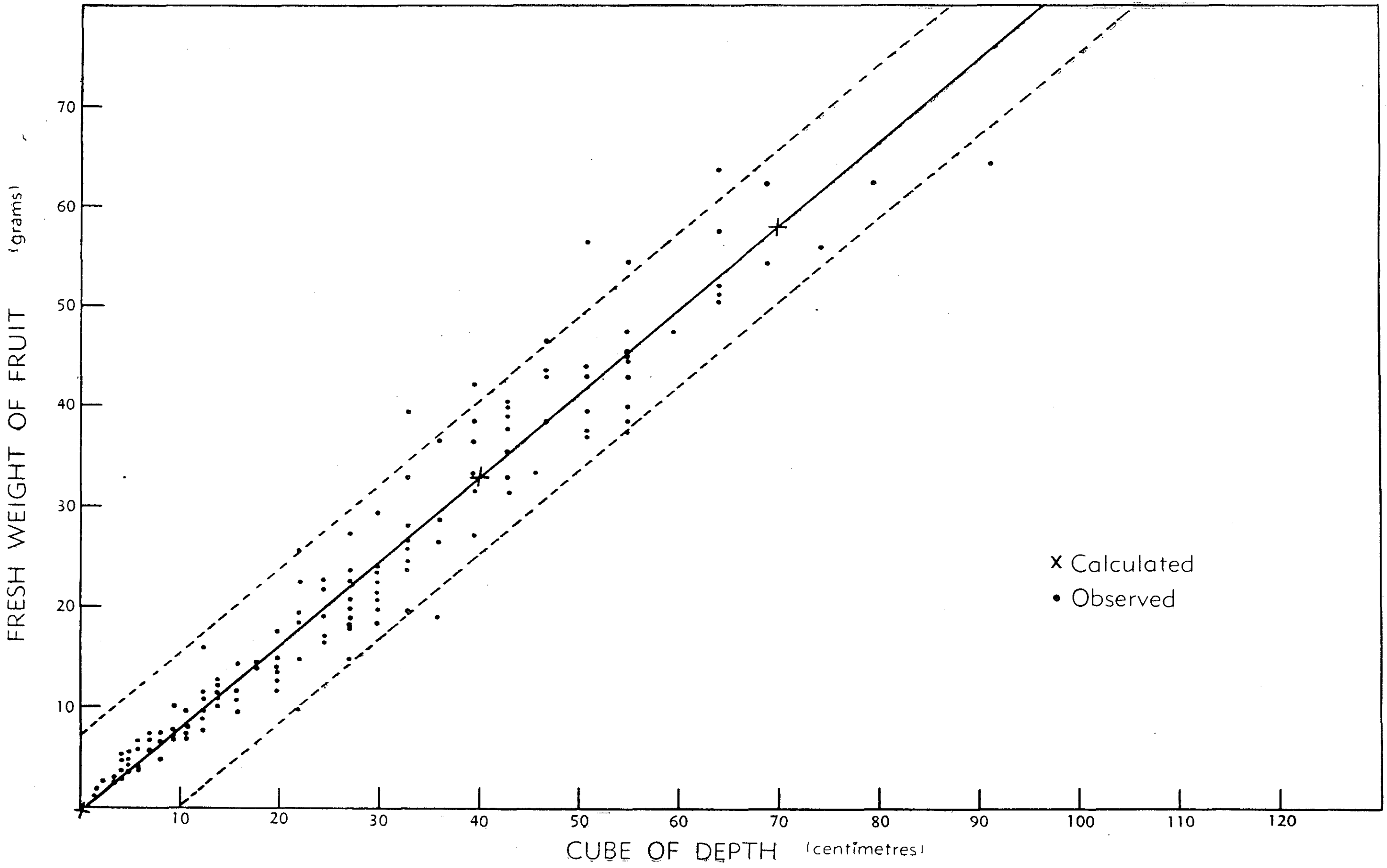

Figure 13.

Showing relationship between fresh weight of fruit and cube of depth of fruit.

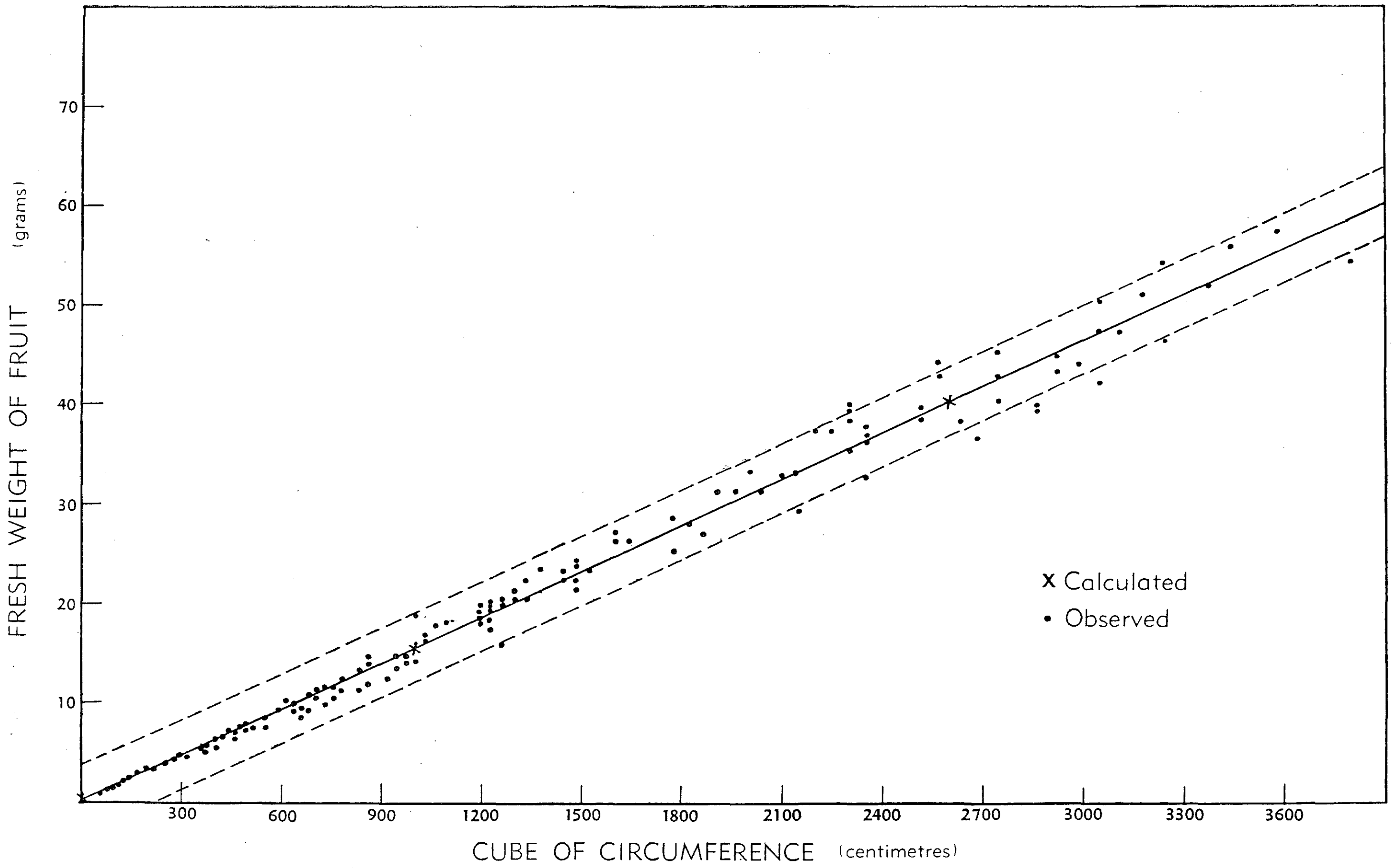

Figure 14.

Showing relationship between fresh weight of fruit and cube of circumference of fruit.

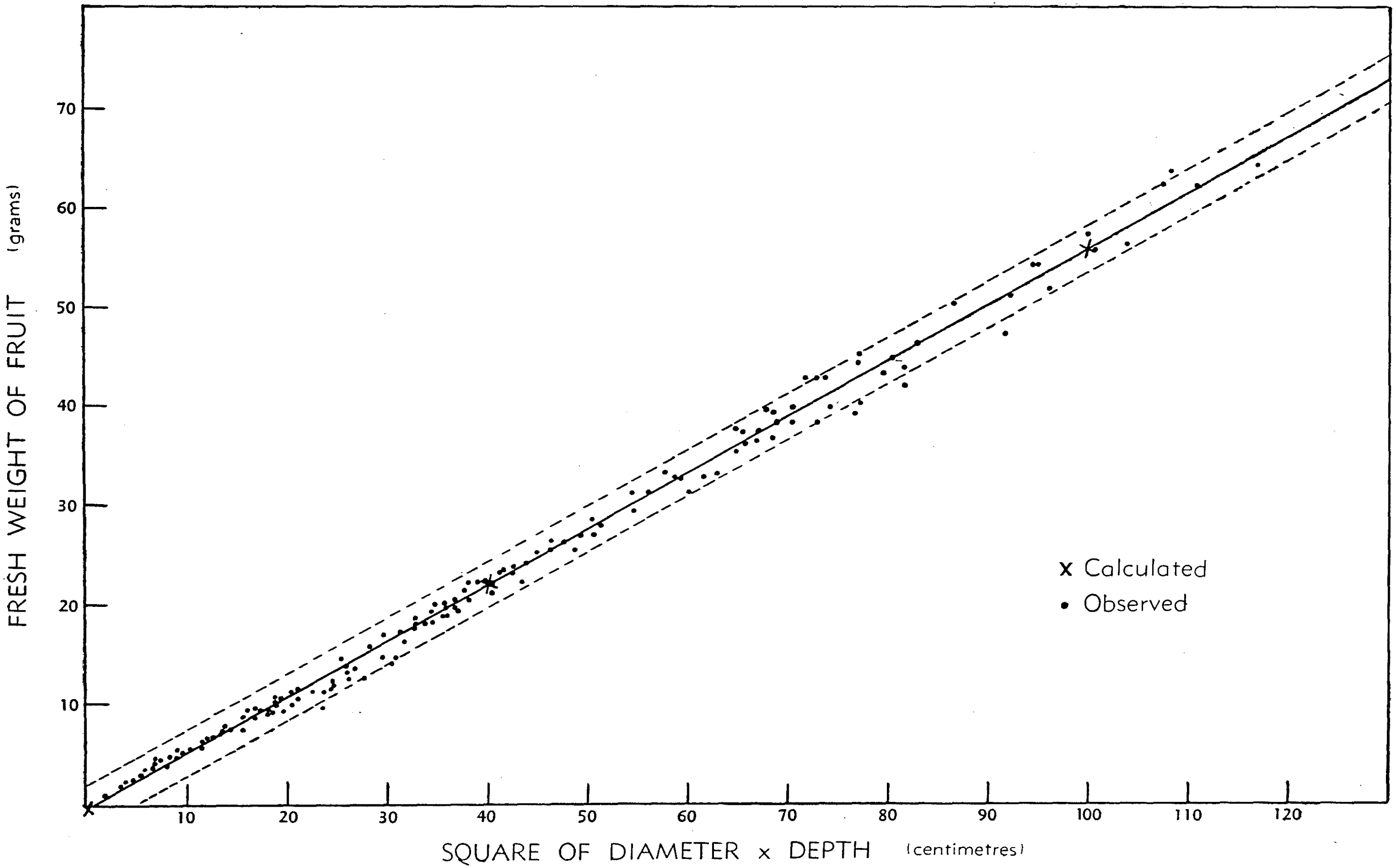

Figure 15.

Showing relationship between fresh weight of fruit and square of diameter x depth.

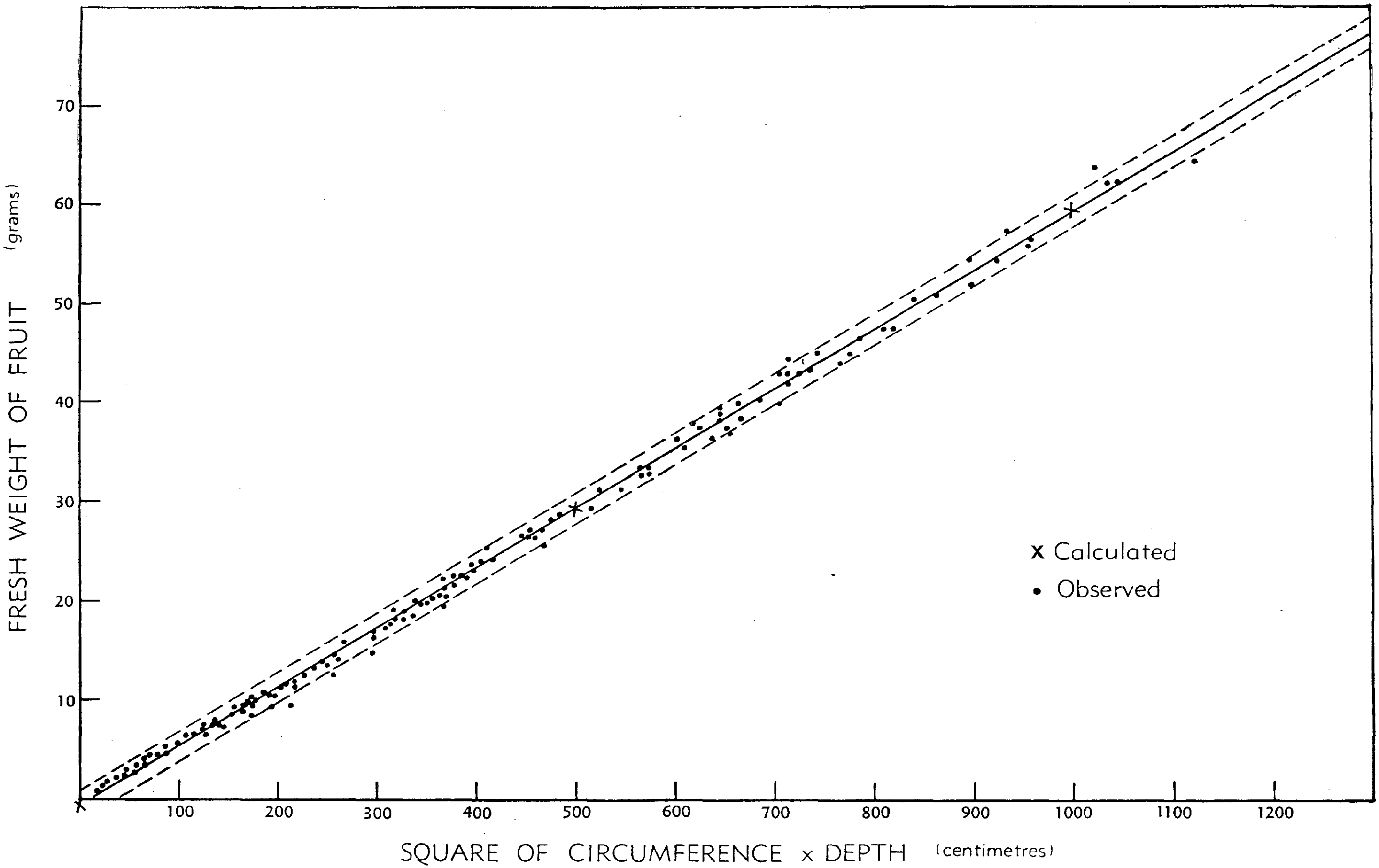

Figure 16.
Showing relationship between fresh weight of fruit and square of circumference x depth.

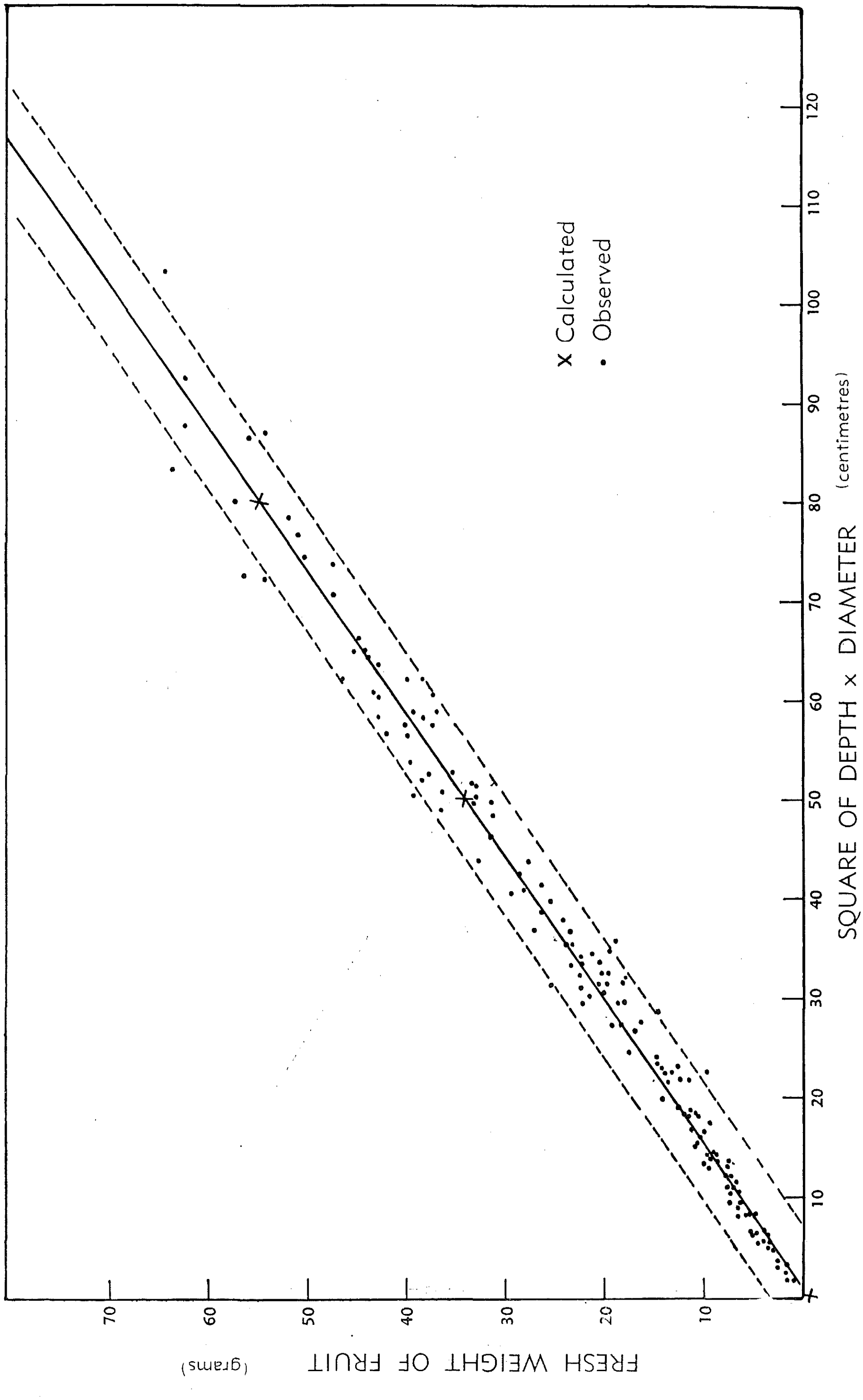

Figure 17.

Showing relationship between fresh weight of fruit and square of depth x diameter.

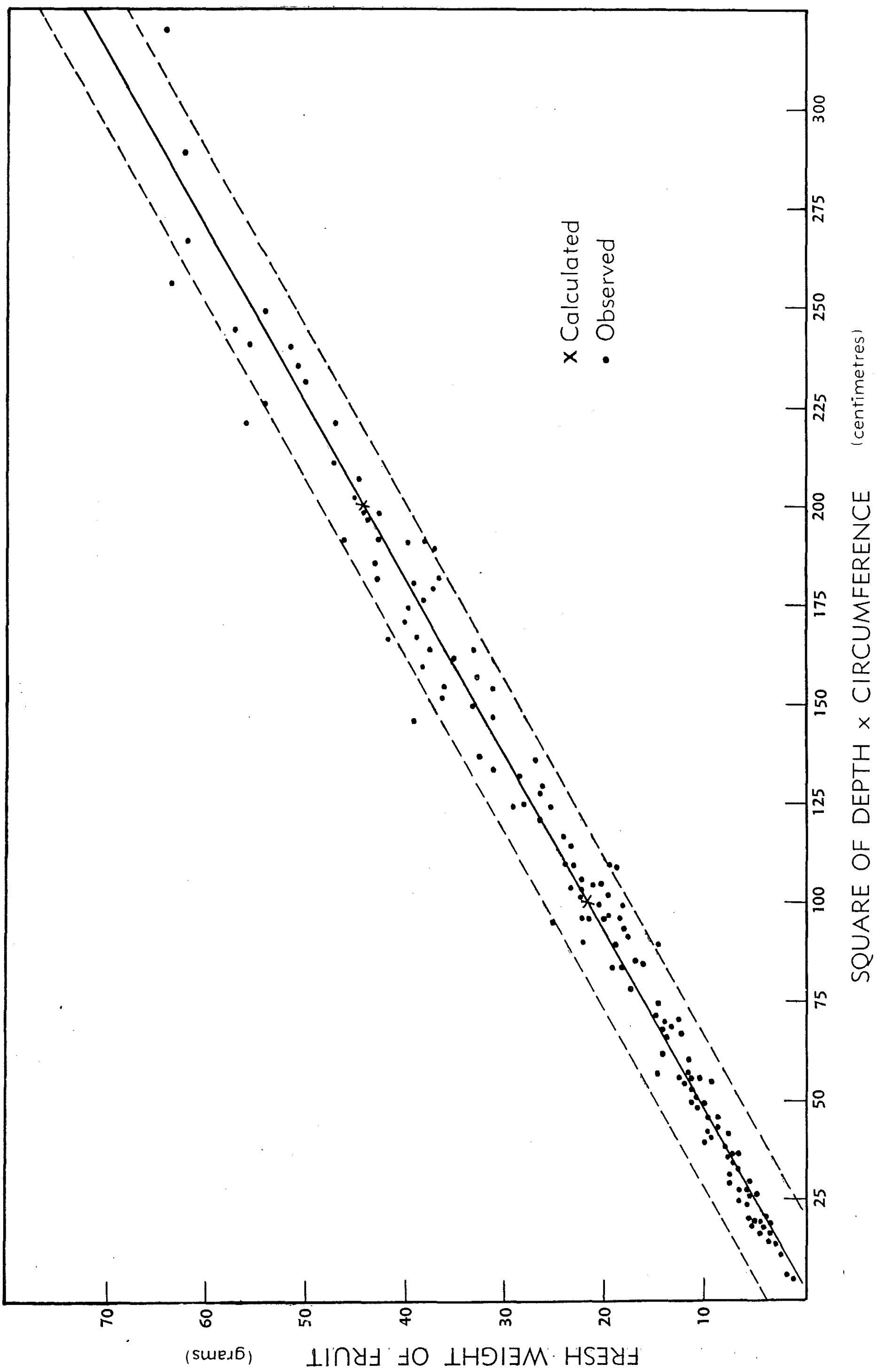

Figure 18.

Showing relationship between fresh weight of fruit and square of depth x circumference.

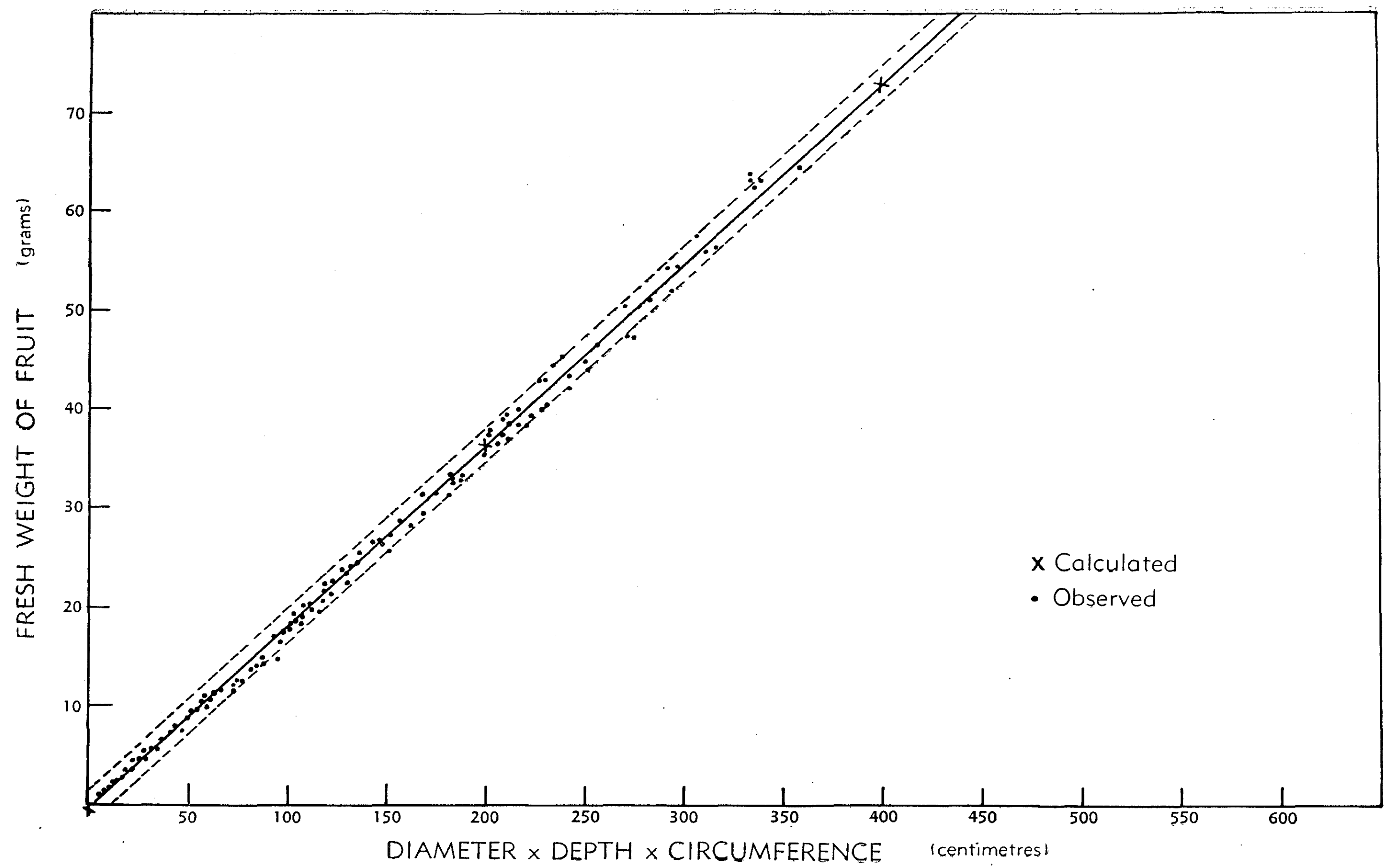

Figure 19.

Showing relationship between fresh weight of fruit and diameter x depth x circumference.

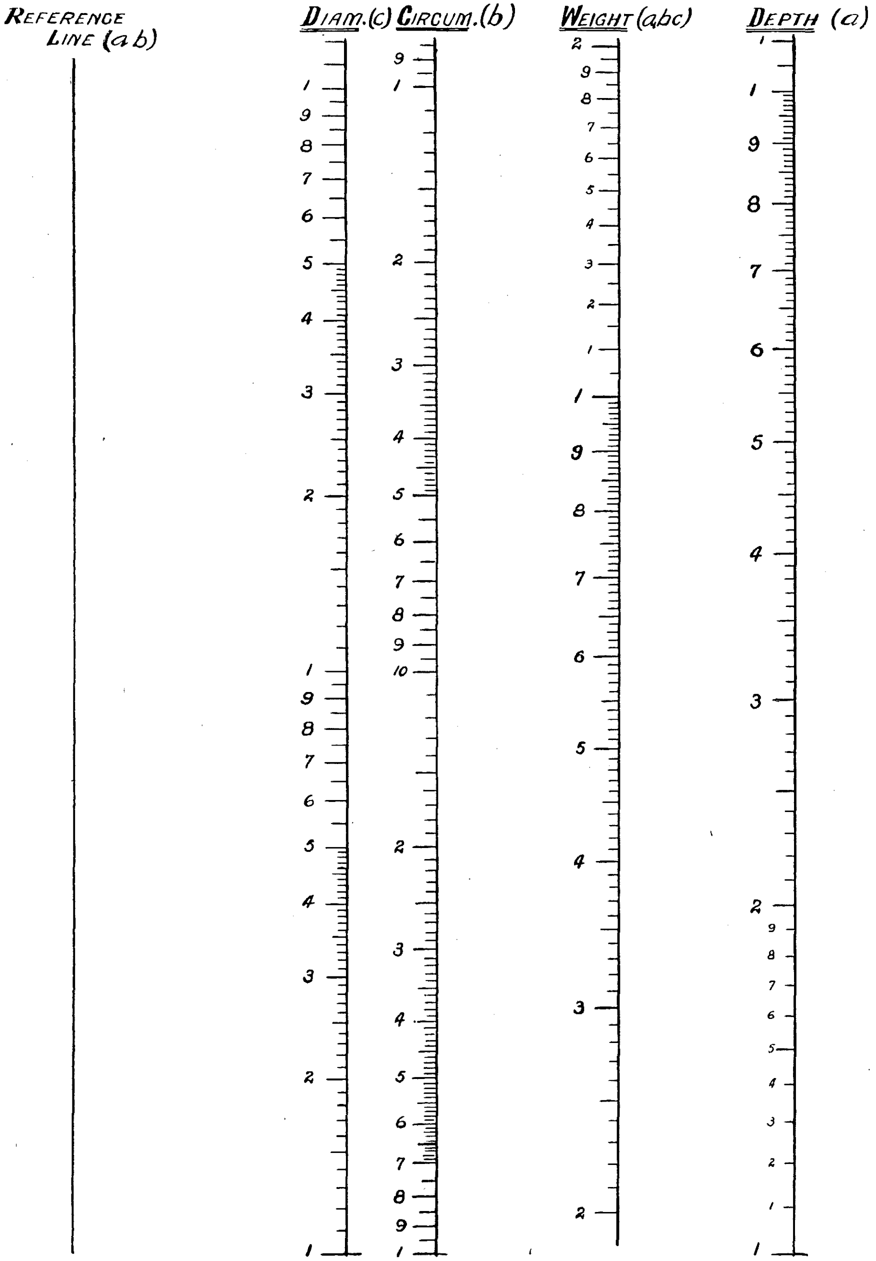

Figure 20.

Nomogram connecting Fresh Weight of a Fruit (in gms.) with its Equatorial Circumference (in cms.) and Depth (in cms.), according to the Equation: Fresh Wt. of Fruit $=$ 0·05985 Circum.^{2} x Depth.

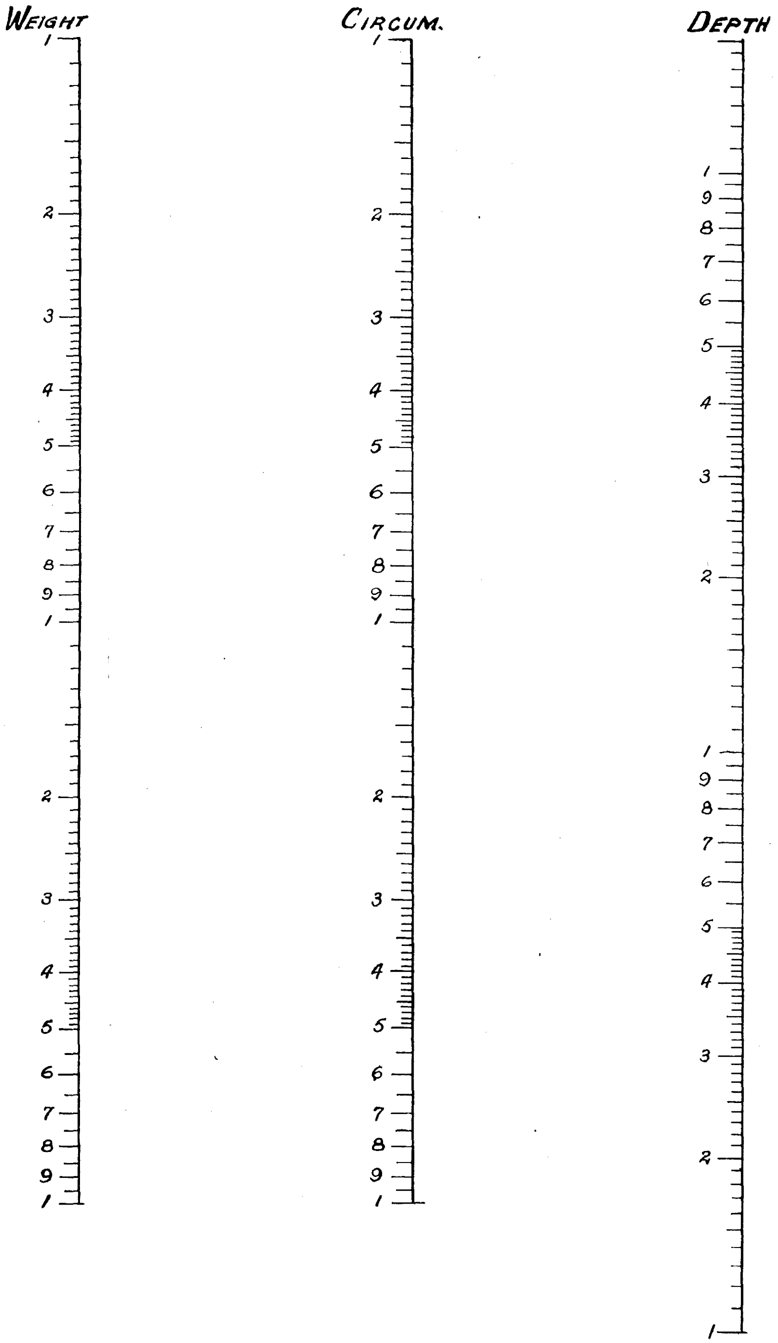

Figure 21.

Nomogram connecting Fresh Weight of a Fruit (in gms.) with its Equatorial Circumference (in cms.), Greatest Equatorial Diameter (in cms.) and Depth (in cms.), according to the Equation: Fresh Wt. of Fruit = 0·18356 (Circum. x Diam. x Depth).

Table 7 that the function *square of circumference* x *depth* provides the most accurate means of estimating weight of fruit. The function *diameter* x *depth* x *circumference* would also yield reliable results, but both this and the function *square of circumference* x *depth* involve the taking of more than one measurement, whereas the function *cube of circumference* will yield the weight from a single reading. There is, however, the possibility that the regression of the two-term functions would more closely fit all varieties of tomatoes than the regressions of a single term function, and with this in mind nomograms (Figures 20 and 21) have been constructed to provide a rapid means of converting these measurements into weight of fruit.

Table 7 reveals that those functions containing the circumference term have comparatively higher values for r and lower for σ than the rest. This might be expected, as the circumference can be regarded as an expression of the mean of all diameters. For most practical purposes, the cube of the circumference will satisfy all requirements of accuracy and it involves the measurement of only one dimension. Appendix 4 has been compiled for the rapid conversion of circumference to fresh weight of fruit.

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APPENDIX 1.

TABLE FOR CALCULATING WEIGHT OF VEGETATIVE PARTS OF PLANT (IN GRAMS) FROM HEIGHT (IN CENTIMETRES) ACCORDING TO THE REGRESSION EQUATION: DRY WEIGHT OF VEGETATIVE PARTS = ·0000334 HT.^{2} − 3·7451.

Ht.	Wt.	Ht.	Wt.	Ht.	Wt.	Ht.	Wr.	Ht.	Wt.
10	3·78	40	5·88	70	15·20	100	37·15	130	77·12
11	3·79	41	6·05	71	15·70	101	38·16	131	78·83
12	3·80	42	6·22	72	16·21	102	39·19	132	80·56
13	3·82	43	6·40	73	16·74	103	40·24	133	82·32
14	3·84	44	6·59	74	17·28	104	41·32	134	84·11
15	3·86	45	6·79	75	17·84	105	42·41	135	85·92
16	3·88	46	7·00	76	18·41	106	43·53	136	87·76
17	3·91	47	7·21	77	18·99	107	44·66	137	89·63
18	3·94	48	7·44	78	19·60	108	45·82	138	91·52
19	3·97	49	7·67	79	20·21	109	47·00	139	93·44
20	4·01	50	7·92	80	20·85	110	48·20	140	95·39
21	4·05	51	8·18	81	21·50	111	49·42	141	97·37
22	4·10	52	8·44	82	22·16	112	50·67	142	99·38
23	4·15	53	8·73	83	22·84	113	51·94	143	101·41
24	4·21	54	9·00	84	23·54	114	53·23	144	103·48
25	4·27	55	9·30	85	24·26	115	54·54	145	105·57
26	4·33	56	6·61	86	24·99	116	55·88	146	107·69
27	4·40	57	9·93	87	25·74	117	57·24	147	109·84
28	4·48	58	10·26	88	26·51	118	58·62	148	112·02
29	4·56	59	10·60	89	27·29	119	60·03	149	114·23
30	4·65	60	10·96	90	28·09	120	61·46	150	116·47
31	4·74	61	11·33	91	28·91	121	62·92	151	118·74
32	4·84	62	11·71	92	29·75	122	64·39	152	121·04
33	4·95	63	12·10	93	30·61	123	65·90	153	123·37
34	5·06	64	12·50	94	31·49	124	67·43	154	125·73
35	5·18	65	12·92	95	32·38	125	68·98	155	128·12
36	5·30	66	13·35	96	33·30	126	70·56	156	130·55
37	5·44	67	13·79	97	34·23	127	72·16	157	133·00
38	5·58	68	14·25	98	35·18	128	73·79	158	135·49
39	5·73	69	14·72	99	36·15	129	75·44	159	138·00

APPENDIX 2.

Table for Calculating Total Dry Weight of Plant (in Grams) from Height (in Centimetres) according to the Regression Equation: Total Dry Weight = ·00005895 Ht.^{3} − 2·5049.

Ht.	Wt.	Ht.	Wt.	Ht.	Wt.	Ht.	Wt.	Ht.	Wt.
10	2·56	40	6·28	70	22·72	100	61·45	130	132·02
11	2·58	41	6·57	71	23·60	101	63·24	131	135·03
12	2·61	42	6·87	72	24·51	102	65·06	132	138·09
13	2·63	43	7·19	73	25·44	103	66·92	133	141·19
14	2·67	44	7·53	74	26·39	104	68·82	134	144·34
15	2·70	45	7·88	75	27·37	105	70·75	135	147·54
16	2·75	46	8·24	76	28·38	106	72·72	136	150·79
17	2·79	47	8·63	77	29·42	107	74·72	137	154·09
18	2·85	48	9·02	78	30·48	108	76·76	138	157·43
19	2·91	49	9·44	79	31·57	109	78·85	139	160·82
20	2·98	50	9·87	80	32·69	110	80·97	140	164·26
21	3·05	51	10·32	81	33·83	111	83·13	141	167·75
22	3·13	52	10·79	82	35·10	112	85·33	142	171·30
23	3·22	53	11·28	83	36·21	113	87·56	143	174·89
24	3·32	54	11·79	84	37·44	114	89·84	144	178·53
25	3·43	55	12·31	85	38·71	115	92·16	145	182·22
26	3·54	56	12·86	86	40·00	116	94·52	146	185·97
27	3·67	57	13·42	87	41·32	117	96·92	147	189·76
28	3·80	58	14·01	88	42·68	118	99·36	148	193·61
29	3·94	59	14·61	89	44·06	119	101·85	149	197·51
30	4·10	60	15·24	90	45·48	120	104·37	150	201·46
31	4·26	61	15·89	91	46·93	121	106·94	151	205·47
32	4·44	62	16·55	92	48·41	122	109·55	152	209·53
33	4·62	63	17·25	93	49·92	123	112·20	153	213·64
34	4·82	64	17·96	94	51·47	124	114·90	154	217·81
35	5·03	65	18·69	95	53·05	125	117·64	155	222·03
36	5·26	66	19·45	96	54·66	126	120·43	156	226·30
37	5·49	67	20·23	97	56·31	127	123·26	157	230·64
38	5·34	68	21·04	98	57·99	128	126·13	158	235·02
39	6·00	69	21·87	99	59·70	129	129·05	159	239·46

N.B.—It is advisable not to use more than three significant figures.

APPENDIX 3.

Table for Calculating Area of Leaf (in Square Centimetres) from Length of Mid-rib (in Centimetres) according to the Regression Equation: Area = $\cdot 29109 L^2 - 6\cdot 80064$.

Length.	Area.	Length,	Area.	Length.	Area.
5·0	·48	20·0	109·64	35·0	349·78
5·5	2·00	20·5	115·53	35·5	360·05
6·0	3·68	21·0	121·57	36·0	370·45
6·5	5·50	21·5	127·76	36·5	381·00
7·0	7·46	22·0	134·09	37·0	391·70
7·5	9·57	22·5	140·56	37·5	402·54
8·0	11·83	23·0	147·19	38·0	413·53
8·5	14·23	23·5	153·95	38·5	424·67
9·0	16·78	24·0	160·87	39·0	435·95
9·5	19·47	24·5	167·93	39·5	447·37
10·0	22·31	25·0	175·13	40·0	458·94
10·5	25·29	25·5	182·48	40·5	470·66
11·0	28·42	26·0	189·98	41·0	482·52
11·5	31·70	26·5	197·62	41·5	494·53
12·0	35·12	27·0	205·40	42·0	506·68
12·5	38·68	27·5	213·34	42·5	518·98
13·0	42·39	28·0	221·41	43·0	531·42
13·5	46·25	28·5	229·64	43·5	544·01
14·0	50·25	29·0	238·01	44·0	556·75
14·5	54·40	29·5	246·52	44·5	569·63
15·0	58·69	30·0	255·18	45·0	582·66
15·5	63·13	30·5	263·99	45·5	595·83
16·0	67·72	31·0	272·94	46·0	609·15
16·5	72·45	31·5	282·03	46·5	622·61
17·0	77·32	32·0	291·28	47·0	636·22
17·5	82·35	42·5	300·66	47·5	649·97
18·0	87·51	33·0	310·20	48·0	663·87
18·5	92·82	33·5	319·88	48·5	677·92
19·0	98·28	34·0	329·70	49·0	692·11
19·5	103·89	34·5	339·67	49·5	706·44

N.B.—It is advisable not to use more than three significant figures.

APPENDIX 4.

Table for Calculating Fresh Weight of Fruit (in Grams) from Circumference (in Centimetres) according to the Regression Equation: Fresh weight of Fruit = ·01540 Circum.^{3} — ·17964.

Cir.	Wt.	Cir.	Wt.	Cir.	Wt.	Cir.	Wt.	Cir.	Wt.	Cir.	Wt.
2·0	0·30	6·0	3·51	10·0	15·58	14·0	42·44	18·0	89·99	22·0	164·16
2·2	0·34	6·2	3·85	10·2	16·52	14·2	44·27	18·2	93·02	22·2	168·67
2·4	0·39	6·4	4·22	10·4	17·50	14·4	46·16	18·4	96·11	22·4	173·27
2·5	0·42	6·5	4·41	10·5	18·01	14·5	47·13	18·5	97·69	22·5	175·60
2·6	0·45	6·6	4·61	10·6	18·52	14·6	48·11	18·6	99·28	22·6	177·94
2·8	0·52	6·8	5·02	10·8	19·58	14·8	50·10	18·8	102·51	22·8	182·71
3·0	0·60	7·0	5·46	11·0	20·68	15·0	52·15	19·0	105·81	23·0	187·55
3·2	0·68	7·2	5·93	11·2	21·82	15·2	54·26	19·2	108·18	23·2	192·48
3·4	0·78	7·4	6·42	11·4	23·00	15·4	56·42	19·4	112·62	23·4	197·50
3·5	0·84	7·5	6·68	11·5	23·60	15·5	57·53	19·5	114·37	23·5	200·04
3·6	0·90	7·6	6·94	11·6	24·22	15·6	58·64	19·6	116·13	23·6	202·60
3·8	1·02	7·8	7·49	11·8	25·48	15·8	60·92	19·8	119·72	23·8	207·79
4·0	1·17	8·0	8·06	12·0	26·79	16·0	63·26	20·0	123·38	24·0	213·07
4·2	1·32	8·2	8·67	12·2	28·14	16·2	65·65	20·2	127·11	24·2	218·44
4·4	1·49	8·4	9·31	12·4	29·54	16·4	68·11	20·4	130·92	24·4	223·89
4·5	1·58	8·5	9·64	12·5	30·26	16·5	69·36	20·5	132·85	24·5	226·65
4·6	1·68	8·6	9·97	12·6	30·99	16·6	70·62	20·6	134·80	24·6	229·44
4·8	1·88	8·8	10·67	12·8	32·48	16·8	73·20	20·8	138·76	24·8	235·08
5·0	2·10	9·0	11·41	13·0	34·01	17·0	75·84	21·0	142·80	25·0	240·80
5·2	2·35	9·2	12·17	13·2	35·60	17·2	78·54	21·2	146·91	25·2	246·63
5·4	2·60	9·4	12·97	13·4	37·23	17·4	81·31	21·4	151·10	25'4	252·54
5·5	2·74	9·5	13·38	13·5	38·07	17·5	82·71	21·5	153·23	25·5	255·53
5·6	2·88	9·6	13·80	13·6	38·92	17·6	84·14	21·6	155·38	25·6	258·55
5·8	3·18	9·8	14·67	13·8	40·65	17·8	87·03	21·8	159·73	25·8	264·65

N.B.—It is advisable not to use more than three significant figures.

A. H. Tucker, Government Printer, Brisbane.