

INVESTIGATIONS INTO THE
TAXONOMY OF CULTIVARS OF
BRASSICA CAMPESTRIS L. VAR.
RAPIFERA METZG. SINSK.

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"Investigations into the Taxonomy of Cultivars of
Brassica campestris L. var. rapifera Metzg. Sinsk."

by
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A Thesis for the Degree of M.Sc.
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I declare that this thesis has been wholly composed by myself and
that it is the result of my own work.

Frank Errington McGuire



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SUMMARY

With the advent of the Plant Variety Rights and Seeds Act of 1964, and with a view to the expected introduction of protection of certain Brassica species in the 1970's, an attempt has been made to deduce the high degree of synonymity which exists at present in turnip cultivars in the United Kingdom.

A comprehensive collection of turnip cultivars being offered for sale on the British market in 1967 was obtained and by using established taxonomic characters together with suggested new criteria of 'bulb' shape and 'bulb' measurements, a detailed classification of the cultivars has been evolved.

Previously turnip cultivars could be divided into 13 main groups (page 75) based on leaf type and bulb colour.

These 13 major groups can now be further sub-divided into another 7, making a total of 20, by using the new taxonomic characters of bulb shape and bulb measurement.

Cultivars previously classed as synonyms can now be identified as distinct.

The genus Brassica, to which our cabbages, kales, Brussels sprouts, cauliflowers, rapes, turnips and swedes belong, is by far the most important of the family Cruciferae from an agricultural point of view. It is remarkable for a wide diversity of forms which are found, and those cultivated in Britain represent only a minor part of the great range of types in existence.

Three primary groups of species exist within the genus, with haploid chromosome numbers of eight, nine and ten. Species with the same haploid number cross freely, but crossing between species with different chromosome numbers usually results in sterile hybrids. However, if chromosome doubling takes place the doubled hybrid (amphidiploid) is fully fertile, and behaves as a new species.

All Brassica species are naturally cross-pollinated, thus care must be taken when seed multiplication is carried out. Isolation between different species and indeed different varieties is necessary to prevent inter-pollination. This heterogenous nature of Brassica crops, also leads to difficulty in maintaining varietal stability and makes roguing for "off-types" within a variety essential. Even with these selection measures, there still exists a high degree of variability within a variety, especially the older ones, which makes varietal identification and description difficult.

Turnips (Brassica campestris L. var. rapifera Metzg. Sinsk.) appear to have been introduced into the United Kingdom from Holland around 1550 for use as a garden crop, while the first reference to the species as a field crop appears in 1686. In 1857 there were 476,691 acres grown in Scotland and reference is made to ten cultivars being grown at this time, while today there are approximately fifty (including homonyms

and synonyms).

It is only in the last few decades that plant breeding has yielded results and now, with the increasing necessity for better quality, higher yield, disease resistant and hardy winter resistant varieties, greater emphasis will be placed on this science.

Prior to 1964, the breeder gained no reward for his industry and once a cultivar was placed in commerce it was available for all to multiply and distribute. As it now takes five to twenty years to produce a new cultivar, coupled with the facts of local and international competition, together with increased costs, it appeared obvious that some form of protection was required.

In 1961 the United Kingdom signed the Convention of Paris for the Protection of New Varieties of Plants. In 1964 the Plant Varieties Rights and Seeds Act was passed through Parliament and schemes for cereals, peas, potatoes, ryegrass, lucerne, roses and certain other ornamental species are now in force. Schemes for Brassicas are to be started in the early 1970's. Such rights, in general, provide that prior authorisation must be obtained from the originator of a produced cultivar before the cultivar can be reproduced for commercial trade. The rights last for a specific period, usually fifteen years, and compensation may be required by the originator.

Before a scheme for a specific crop is put into operation certain preliminaries are necessary. These are aimed at clearing up synonymy and homonymy of cultivars of the species in question. There are three stages in the process culminating in compilation of an Index, which is a list of distinct cultivars of a specific crop at present in commerce in the United Kingdom. Before a cultivar can be sold or offered for sale it must be on the Index.

With the formulation of the Index a Plant Varieties Rights Scheme is brought into operation and new cultivars, providing they fulfil the requirements of being (1) sufficiently distinct from any other known cultivars, (2) sufficiently homogenous and (3) sufficiently stable in important characters after reproduction, can gain protection. With regard to cross-fertilising crops such as turnips, although not negligible, the stimulus for protection is not so great as that in self-fertilising crops, as the breeder is more or less able to control the major output of seed of his strain.

It is with a view to the future, therefore, that the following work attempts to evaluate a method of distinguishing cultivars of Brassica campestris L. var. rapifera Metzg. Sinsk. and to form classification of those cultivars at present in commerce in the United Kingdom.

LITERATURE REVIEW

The genus Brassica has received much attention from taxonomists since it was created by Linnaeus in the eighteenth century. Although in the nineteenth century controversy centred around the Linnaean division of Brassica and Sinapis, and attempts were made to combine them into one genus, the two are now regarded as distinct genera.

Early investigations centred round seed-coat taxonomy with emphasis on the epidermal layers. Until fairly recently there was some conflict regarding the nomenclature of the turnip, but now the one used by Olsson (1954) - Brassica campestris L. var. rapifera Metzg. Sinsk. - in his classification of the Campestris group of the genus Brassica, is generally accepted.

Pieters and Charles (1901) claimed to find differences between the species of Brassica oleracea, Brassica napus, Brassica nigra and Brassica arvensis using seed-coat and epidermal layer taxonomy.

Of the most recent work on seed taxonomy within the genus, McGugan (1946), Musil (1948) and Berggren (1962) gave detailed accounts and full classification at the species and sub-species level.

From the use of seeds and seedlings as a basis for classification of the genus, interest focused on the mature plant as a subject for taxonomic study.

Engler (1919) retained the Linnaean division of Brassica and Sinapis into separate genera and classified thirty-five species within the genus Brassica and seven in Sinapis, while Bailey (1922), using six morphological characters confirmed Engler's work.

Pearson (1928) was the first author to suggest classifying the genus on the basis of chromosome numbers. Nogai and Sasoga (1930), Karpenchenko (1930) and Morinaga (1930) all made exhaustive determinations of chromosome numbers resulting in the formulation of seven groups within the genus. Morinaga (1930), investigating the cytology of the inter-specific hybrids of Brassica, showed that three fundamental chromosome sets were present. These haploids with chromosome complements of eight, nine and ten were elementary species and those others which were derived from two elementary species were called amphidiploid. Crane (1943) and Chopinet (1949) investigated the genetic relationships between species of Brassica and hypothesised the origin of certain sub-species.

Sun (1946), using sixteen morphological characters, in conjunction with studies of genetics and cytology, has made a full classification of the genus. Schuphan and Weinmann (1956), Korohoda et al. (1958), Fukushima and Inasa (1966) used chromatographic techniques for identification of plants at the species level.

Curran (1962) in his "Nature of our Brassica Crops" summarised the nomenclature and cytology with special relevance to Western European groups.

Taxonomic investigation of the cultivars are far fewer than at the specific and generic level.

Heydel and Früter (1964) described a new method of differentiating between species and cultivars of rape, turnip rape and swedes. The characteristic difference which, together with the known characteristics, i.e. netting, lumen width and cellular size, are found by measuring and counting the palisade cells in the median contact zone between the micropyle and the navel. Significant distinctions between cultivars of the species investigated were not found.

Shibutani and Okamura (1954) studied anatomical features of the

seed-coat and classified the turnips in Japan on the types of epidermal layers of the seed.

Seed types:-

A - Swelling of cells when H_2O is absorbed.

B - Epidermal layer is seen only as membrane -
indistinct feature.

AC)
BC) - Both have distinct pigment layers.

Turnips classified as A - Western European group.

B - Intermediate group.

C - Japanese group.

However, they were unable to be split any further than these groups, using this method. In conjunction with their work carried out on seed-coat anatomy they also examined morphological characters of the seed stages, i.e. form and colour of seeds, size and shape and network of seed-coat for classification and identification, mainly, however, at the species level.

Aoba (1961) described sixteen locally grown Japanese turnip varieties.

Inque and Shibuya (1951), using three season's data on the flower-bud formation in turnips, found considerable differences between varieties ranging from fifty to sixty-five days. On this basis varieties were classified into four groups. Similar work was carried out by Shibutani and Isoda (1958) on forty varieties (Japanese and Western European) of turnip and a striking difference was found between the two groups. The range was forty to sixty-five days, with the Western European types taking longer to flower-bud formation than the Japanese. Only minor differences between cultivars within the two types were found.

Davey (1946) classified swede varieties using morphological

characters, i.e. flesh colour, skin colour, shape, maturity and hardness; while Chamberlain (1949) investigated the varietal resistance of swedes to turnip mosaic.

In an effort to clear up synonymy in swede and turnips in New Zealand, Wallace (1953), using the same characters as Davey and Chamberlain, classified them into six cultivars of swedes and eleven of turnips.

Krzymański (1965) investigated fatty acid content of B. napus and B. campestris (winter rapeseed) using chromatographic quantitative determinations. It was found that cultivars differed significantly in respect of the content of all fractions of fatty acids in B. napus, while in B. campestris significant differences were found only for linoleic, linolenic and erucic plus arachidic fractions. Influence of environment on the content of the oleic plus palmitic and the linoleic acid fractions in B. campestris was statistically proved.

Babičev (1953) observed in varieties of turnip, swede, beet and carrot, differences in invertase activity which were correlated with the type of sugar present. Those with high invertase activity have mainly reducing sugars, while those with low activity, mainly sucrose. Sebalina (1962), in his paper on the problems of turnip breeding, suggested that future work should be directed towards an increase in content of ascorbic acid, sugar and minerals, while Khan (1964) showed differences between turnip varieties and their hybrids in these fractions. Allison and Wright (1966) carried out work on similar lines on Kale cultivars. It was shown that cultivars showed significant differences in minerals, total nitrogen and cellulose content.

Vaughan et al. (1966) carried out comparative studies of the seed proteins of B. campestris, B. oleracea and B. nigra. The albumin and globulin fractions of the seeds of the above species was investigated

using serological methods and separation by acrylamide gel electrophoresis in order to determine the usefulness of these techniques for taxonomic studies of the genus Brassica. The results of the protein analysis agree with established taxonomy and suggest that both methods may prove useful for further studies in the genus. The serological results showed that a species relationship existed and differences in the reactions suggest and support the theory that plants belong to three distinct species. The results of the acrylamide gel separation agrees with the serological results and suggest that there is a closer relationship between B. oleracea and B. campestris than either with B. nigra.

Josefsson (1967), in his investigation, presented evidence that thiocyanate-yielding glucosides in Brassica crops is partly genetically controlled, while Johnston and Jones (1966) found significant inter-varietal differences in the thiocyanate content of kale cultivars.

As can be seen, most of the important taxonomic work has been done at the species and generic level. While some investigations have been carried out on cultivars, mainly by Japanese workers, the results are of limited value and not sufficiently detailed. The following thesis attempts to clarify synonymity and homonymity of turnip cultivars which exist at present in the United Kingdom.

MATERIALS AND METHODS

In an effort to clear up synonymity and homonymity which exists in turnip cultivars in the United Kingdom, a comprehensive survey of all known cultivars was carried out over the years 1967-68. A complete collection of cultivars being offered for sale by British seed firms was obtained, and in the case of the more popular cultivars, seed was ordered from a few sources. The cultivars used in the experiments were:-

	<u>Source of Seed</u>	
Early Snowball	Buntings	1966
Early Snowball	Carters	1966
Early Snowball	Hursts	1966
Clibrans White Ball	Dickson, Brown and Tait	1968
Tennis Ball	Fogwills	1968
Early Milan	Fogwills	1968
Early Milan	Carters	1968
Early Milan	Hursts	1968
Model White	Arnolds	1968
Model White	Kings	1968
Model White	STS 2087	1965/66
Milan Pure White	STS 2090	1965/66
Early White Stone	Buntings	1966
Early White Stone	Hursts	1966
White Globe	Hursts	1966
Pommeranian White Globe	D.B.T.	1968
Pommeranian White Globe	Grays	1968
Pommeranian White Globe	D.B.T.	1968
Little Marvel	Carters	1966
Early Market	Arnolds	1968
Tokyo Market	Roberts	1968
Harbinger	Dickson, Brown and Tait	1968
Strap-leaved Early White Top	W.S.	1968
Orange Jelly	Carters	1968
Orange Jelly	Hursts	1968
Golden Ball	Hursts	1968
Golden Ball	Buntings	1968
Golden Ball	Clucas	1968
Golden Stone	Buntings	1968
Golden Rose	Carters	1968
Golden Wonder	Ryders	1968
Golden Sunrise	Carters	1968
Golden Perfection	Arnolds	1968
Utility	Unwins	1968
Milan Purple Top	Clucas	1966
Milan Purple Top	Buntings	1966
Purple Top Mammoth	STS 350	1965/66
Purple Top Mammoth	Hursts	1966
Purple Top Mammoth	Clan Seeds	1966

Source of Seed

Purple Top White	Marquands	1966
Purple Top White	Fogwills	1966
White Greystone	Grays	1966
Greystone	STS 7606	1965/66
Devonshire Greystone	Hursts	1966
Blue Cap	Clucas	1966
Lincoln Red Globe	Hursts	1966
Lincoln Red Globe	Rough head and Park	1966
Lincoln Red Globe	Clucas	1966
Veitch's Red Globe	Buntings	1966
Red Globe	STS 475	1965/66
Red Globe	Carters	1966
Milan Red Top	Marquands	1966
Milan Red Top	S. Dobie	1966
Milan Strap-Leaved P.T.	W.S.	1968
Red American Strap-leaved	Carters	1968
Manchester Market	Buntings	1968
Manchester Market	Carters	1966
Green Globe	Clucas	1966
Green Globe Imperial	D.B.T.	1968
Green Ring	Locks	1968
Norfolk Green Round	Buntings	1968
Norfolk Green Round	Hursts	1968
Marble Green Top Stone	N.W.	1968
Marble Green Top Stone	Buntings	1966
Early Green Top Stone	Carters	1966
Early Green Top Stone	Buntings	1966
Early Green Top Stone	Hursts	1966
Green Round	Fogwills	1966
Green Round	Hursts	1966
Prizetaker	Carters	1966
Green Tankard	Hursts	1966
Yellow Tankard	Little and Ballantyne	1966
Yellow Tankard	Hursts	1966
Bortfelder	Clan Seeds	1966
Bortfelder	Roughhead and Park	1966
Bortfelder	Grays	1966
Harrison's Improved Green		
Barrel	Clucas	1966
Wallace	Roughhead and Park	1966
Wallace	Clan Seeds	1966
Green Top Scotch	D.B.T.	1968
Fosterton Hybrid	Roughhead and Park	1968
Fosterton Hybrid	Clan Seeds	1968
Balmoral	S.A.I. Ltd.	1968
Sheepfold Yellow	STS 344	1965/66
Cropwell Green Top	Clan Seeds	1966
Aberdeen Green Top	Grays	1966
Aberdeen Green Top	Little and Ballantyne	1966
Grampian	Gartons	1968
All the year round	Carters	1968
Challenger	Clan Seeds	1968
Yellow Perfection	Pennells	1968

	<u>Source of Seed</u>	
McCombies Yellow	Roughead and Park	1968
Invincible	Carters	1968
Champion Green Top	Arnolds	1967
Purple Top Yellow	STS 2201	1965/66
Purple Top Yellow	Grays	1966
Purple Top Scotch	Clucas	1966
Purple Top Scotch	Hursts	1966
Bruce	Roughead and Park	1966
Bruce	Clan Seeds	1966
Bruce	STS 345	
Tammy Mackie	Grays	1966
Tammy Mackie	Hursts	1966
Renown	Clan Seeds	1966
Chieftain	Little and Ballantyne	1966

Prior to sowing the cultivars were split into six groups based on bulb colour. No other characters were used to split the varieties (cultivars) up into smaller groups at this stage, as this would have led to an impractical layout in the field.

The groups were as follows:-

- VA - All white bulb
- VB - Green top -white base
- VC - Green top - cream or yellow base
- VD - Green or pale green/cream - orange base
- VE - Purple top - white base
- VF - Purple top - yellow base

<u>Plot Number</u>	<u>Variety</u>	<u>Sample</u>	
VA	1. Early Snowball	Watkin and Simpson	1967
	2. Little Marvel	Carters	1967
	3. Early Market	Arnold's	1967
	4. Model White	S. Dobie	1967
	5. Pommeranian White	Hursts	1967
	Globe		
	6. Clibrans White Ball	Dickson, Brown and Tait	1967
VB	7. Harbinger	Dickson, Brown and Tait	1967
	1. Green Top Stone	Watkin and Simpson	1967
	2. Green Tankard	Hursts	1967
	3. Harrison's Improved	Clucas	1967
	Green Barrel		
	4. Green Globe	Hursts	1967
	5. Norfolk Green Round	Watkin and Simpson	1967
6. Manchester Market	Watkin and Simpson	1967	
7. Strap-leaved Early	Watkin and Simpson	1967	
White Top			

<u>Plot Number</u>	<u>Variety</u>	<u>Sample</u>	
VC	1. All the Year Round	Carters	1967
	2. Wallace	Hursts	1967
	3. Fosterton Hybrid	McNairs	1967
	4. Sheepfold Yellow	McNairs	1967
	5. Cropwell Green Top	McNairs	1967
	6. Aberdeen Green Top	Hursts	1967
	7. Yellow Tankard	Hursts	1967
	8. Bortfelder	Roughead and Park	1967
VD	1. Golden Ball	Hursts	1967
	2. Golden Sunrise	Carters	1967
	3. Golden Stone	Finney's	1967
	4. Golden Rose	Carters	1967
	5. McCombies Yellow	Roughead and Park	1967
	6. Glenlogie	McNair	1967
	7. Challenger	McNair	1967
	8. Yellow Perfection	Pennell's	1967
VE	1. Blue Cap	Clucas	1967
	2. Purple Top White	Ryders	1967
	3. Lincoln Red Globe	Hursts	1967
	4. Red Globe	Carters	1967
	5. Purple Top Mammoth	Hursts	1967
	6. Greystone	Hursts	1967
VF	1. Purple Top Yellow	STS 2024	1966/67
	2. Purple Top Scotch	Clucas	1967
	3. Renown	McNair	1967
	4. Bruce	Roughead and Park	1967

The cultivars were then sown out in the field in two separate experiments.

Sowing date 1967 - 1st to 2nd May

Sowing date 1968 - 31st May

Time of sowing affected the plots as will be seen later on in the results. In 1967 the cold period during the middle to end of May, caused some of the cultivars to "bolt" thus making the recording of details impossible, whereas in 1968, the sowing date was held back and no "bolting" was recorded on any cultivar at maturity.

CULTURAL DETAILS OF EXPERIMENT 1

Seed of every cultivar collected was pre-dressed with Gammalex and sown out in the field on the ridge. Each plot was ten yards long by two drills, and the plants were 'singled' at the seedling stage to ten to twelve inches. The plants were allowed to mature, and full descriptions, using the following characters, were taken at this stage.

Foliage - 1. Size

2. Habit
3. Leaf type
4. Leaf shape - (entire leaf only)
5. Number and size of lobes - (Lyrate leaf only)
6. Colour
7. Presence of hairs

Bulb or Root - 1. Size

2. Shape
3. Colour (Figures 1 to 9)
4. Skin texture
5. Shoulder and base shape
6. Presence of side roots
7. Type of 'tap' root
8. Flesh colour

General Characters - 1. Maturity

2. Uniformity
3. Other useful information

Descriptions for each cultivar are given in the Appendix.

These results, together with those from the other experiments form the complete classification of varieties given on pages 75 to 77.

FIGURE 1



WHITE

GREEN TOP
WHITE



FIGURE 2

FIGURE 3



GREEN TOP
YELLOW

GREEN TOP
ORANGE



FIGURE 4



FIGURE 5

CREAM TOP
ORANGE

FIGURE 6



PURPLE TOP
WHITE



FIGURE 7

FIGURE 8

PURPLE TOP
GREEN-WHITE



PURPLE TOP
YELLOW



FIGURE 9

CULTURAL DETAILS OF EXPERIMENT 2

The cultivars in each major group (VA-VF) were sown out using a random plot design, six replicates of each cultivar. Plot size was five yards long by four drills, and were sown on the ridge as in Experiment 1. Each plot was singled at the seedling stage to ten to twelve inches between plants and then left until maturity, when the following recordings were taken.

1. Subjective record of shape - twenty bulbs per plot.
2. Measurement of height of bulb at the longest point.
3. Measurement of width of bulb at the widest point - ten bulbs per plot.
4. Measurement of height of foliage (longest leaf in each case) - ten plants per plot (1968 trial only).

MEASUREMENTS

1. Shape - Each bulb was scored from one to six according to the following "Shape Scale".

1. Flat
2. Round
3. Globe
4. Semi-tankard
5. Oval-triangular
6. Tankard

(see figures 10 to 15)

and a mean figure for each plot was obtained.

FIGURE 10



FLAT

ROUND



FIGURE 11

FIGURE 12



GLOBE

SEMI-TANKARD



FIGURE 13

FIGURE 14

OVAL
TRIANGULAR



TANKARD



FIGURE 15

Example of Shape
Analysis of Variance carried out on Average Plot Figures
1967 Records for Variety VA.1

1 = Flat 2 = Round 3 = Globe 4 = Semi-Tankard 5 = Oval Triangular 6 = Tankard

Untransformed Data

7 1 7 2 3 -

Transformed Data

7 2 21 8 15 -

Total = 53

Average Plot Figure = $53 \div 20 = 2.65$

2. and 3. Measurements of Bulb - The measurements of the height and the diameter were used to give a figure of height/diameter ratio for each bulb. These were then averaged to give a mean figure per plot. The figures of height and diameter were also analysed separately to give an indication of bulb size.

4. Foliage Height - These measurements were carried out in 1968 only and an average figure for each plot was calculated.

STATISTICAL TECHNIQUES

Analysis of variance was completed for the characters of:-

1. Shape
2. Bulb Height } Size
3. Bulb Width } Size
4. Height/Diameter Ratio of the Bulb
5. Foliage Height (1968 only)

in all groups each year. The following is a sample method for shape.

Example of Analysis of Variance of Shape Group VA

$$\text{Correction Factor} = \frac{76.85^2}{36} = 164.05$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
Between Vars. S.S. = 170.10 - 164.05 = 6.05	5	1.21	30.25	2.60	3.86
Between Reps. S.S. = 164.52 - 164.05 = 0.47	5	0.09	2.25		
Error S.S. = 0.98	25	0.04			

The figures used in each case were plot means. Replication variance was tested against error variance and in every case of shape, height, width and height/diameter ratio was found to be non-significant, but it was significant in the case of foliage, presumably because this is a more variable character.

The least significant difference was calculated and corresponding values of 't' were used to test the five and one per cent levels of significance.

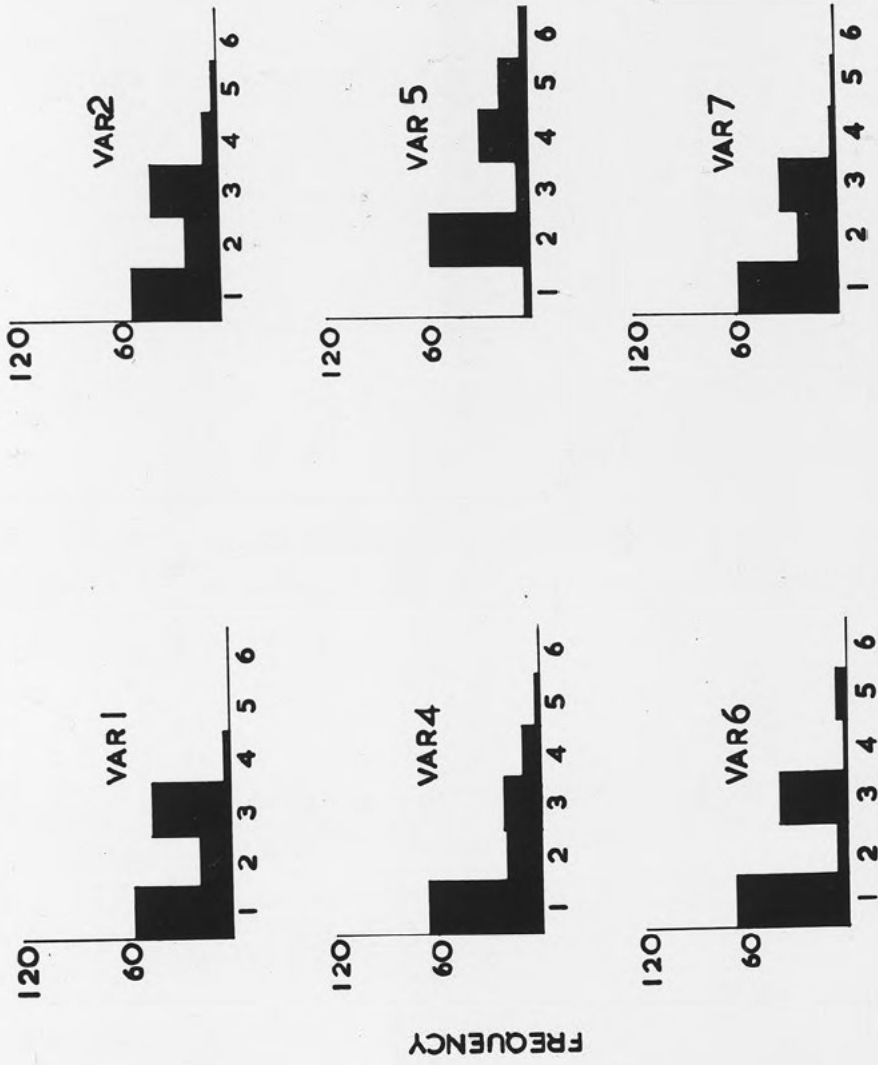
Histograms

Histograms for the bulb shape character were completed in each variety each year. Frequency was plotted against bulb shape, using one hundred and twenty recordings per variety. The histograms give an indication to the range of variability both within varieties for each year, and between year variation, presumably caused by environmental effects.

In general, the histograms show a normal distribution with a tendency towards a skew, which is common in biological material. They illustrate a fair amount of variation which was to be expected of a crop which is naturally cross-fertilised. They also show that in general the variation of the same cultivar between years is fairly small. This tends to indicate that, on the whole, environmental effects do not greatly affect bulb shape, when care is taken with the cultural aspects of the experiment such as depth of sowing, singling and weed control.

HISTOGRAMS OF BULB SHAPE 1967

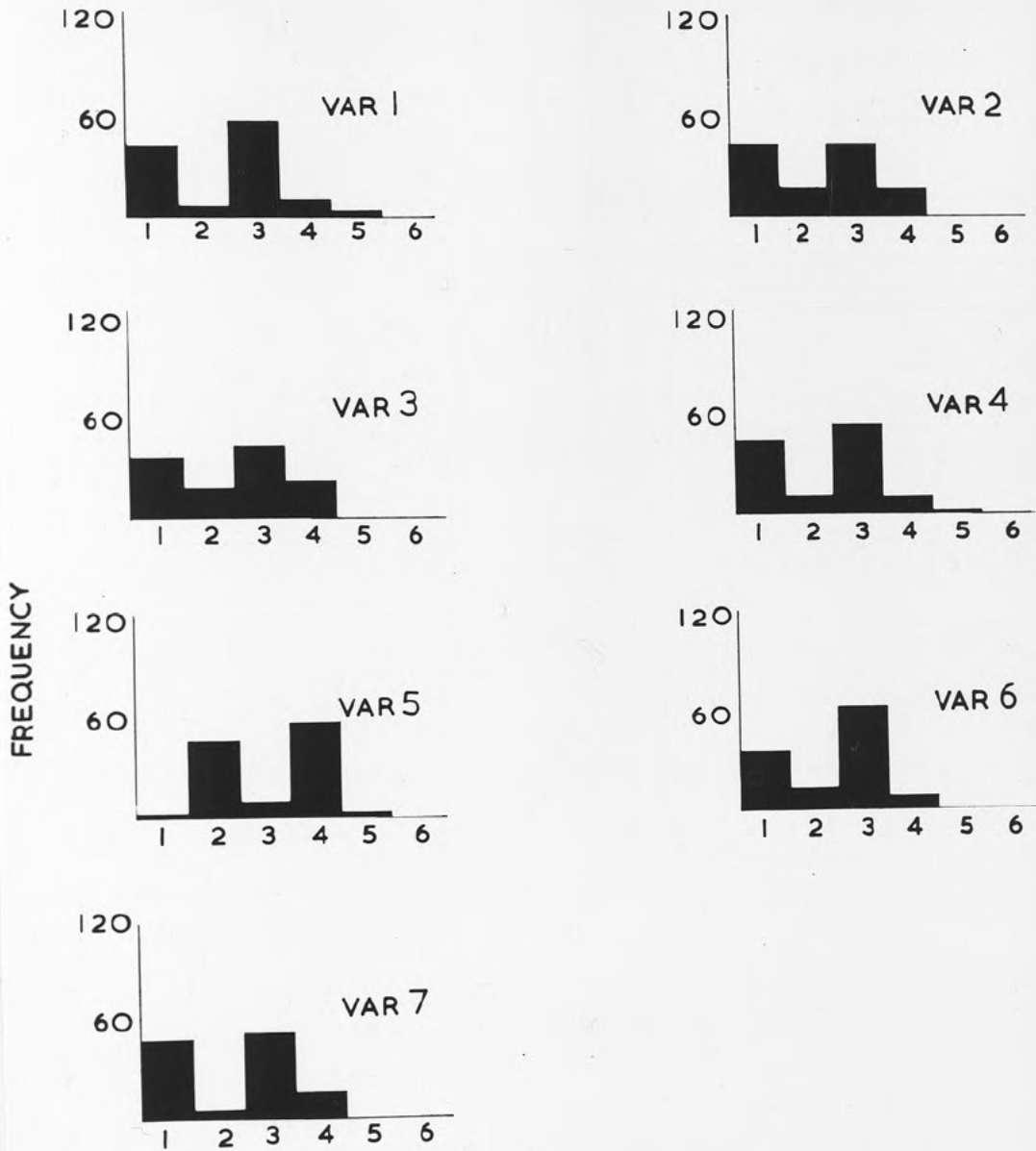
FREQUENCY DISTRIBUTION



GROUP VA

FIGURE 16

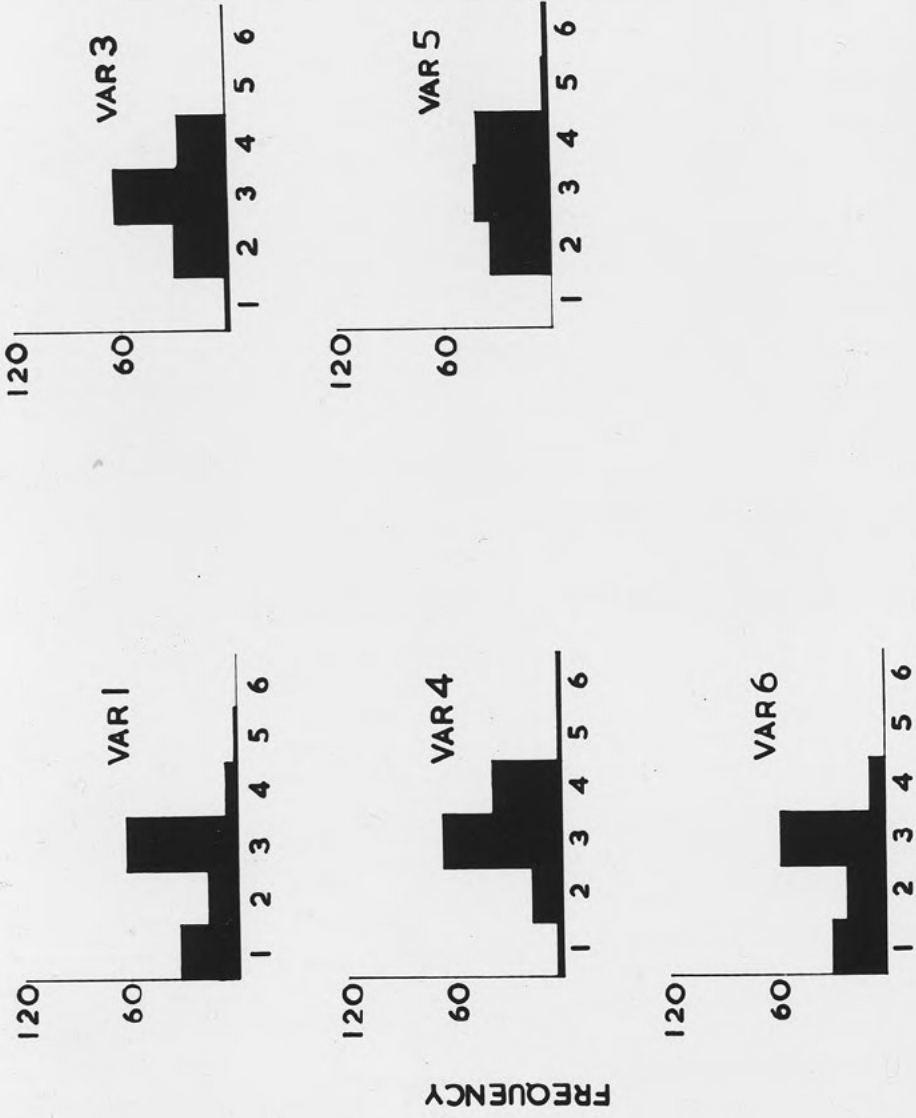
FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968



GROUP VA

FIGURE 17

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1967



GROUP VB

FIGURE 18

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968

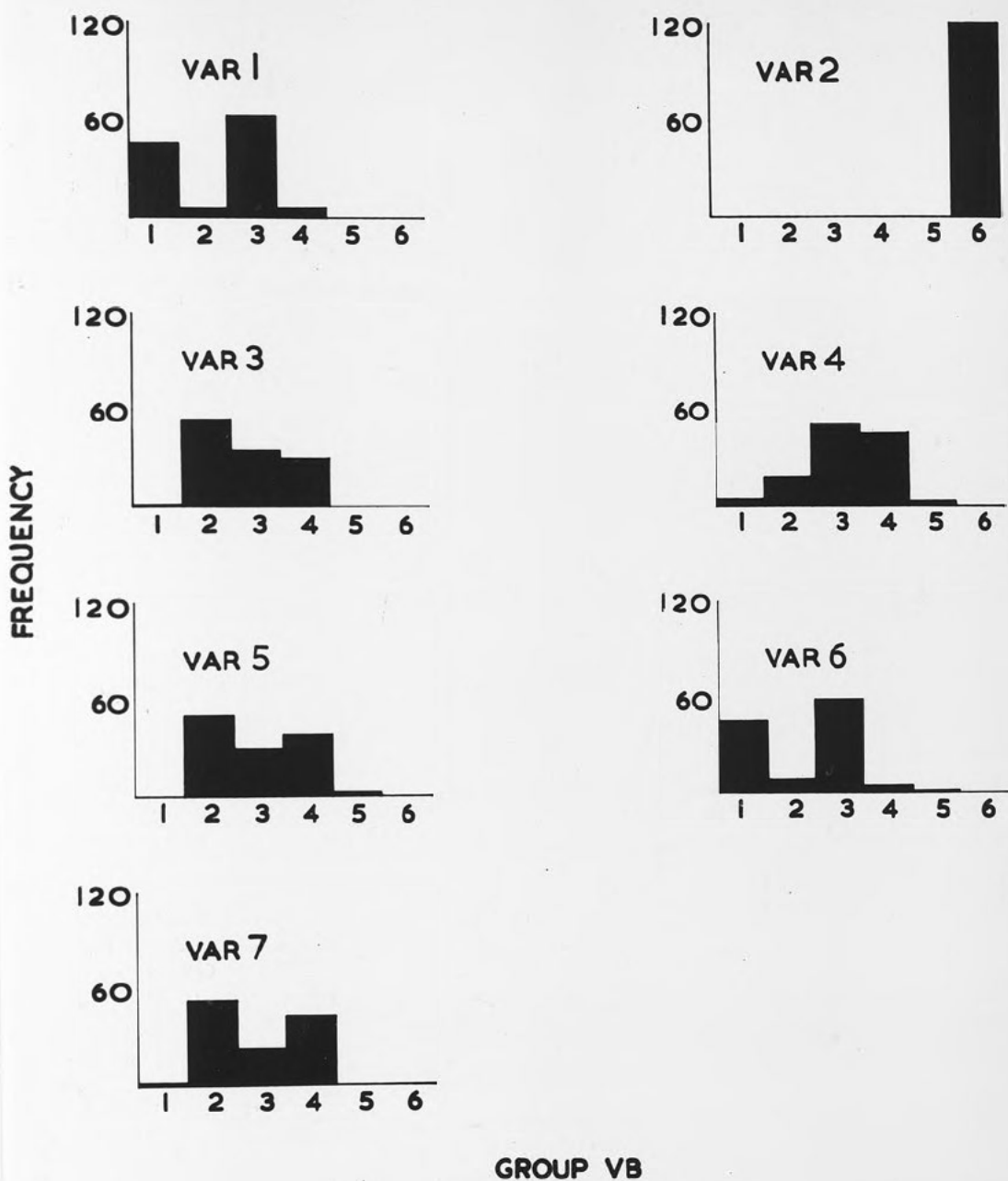


FIGURE 19

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1967

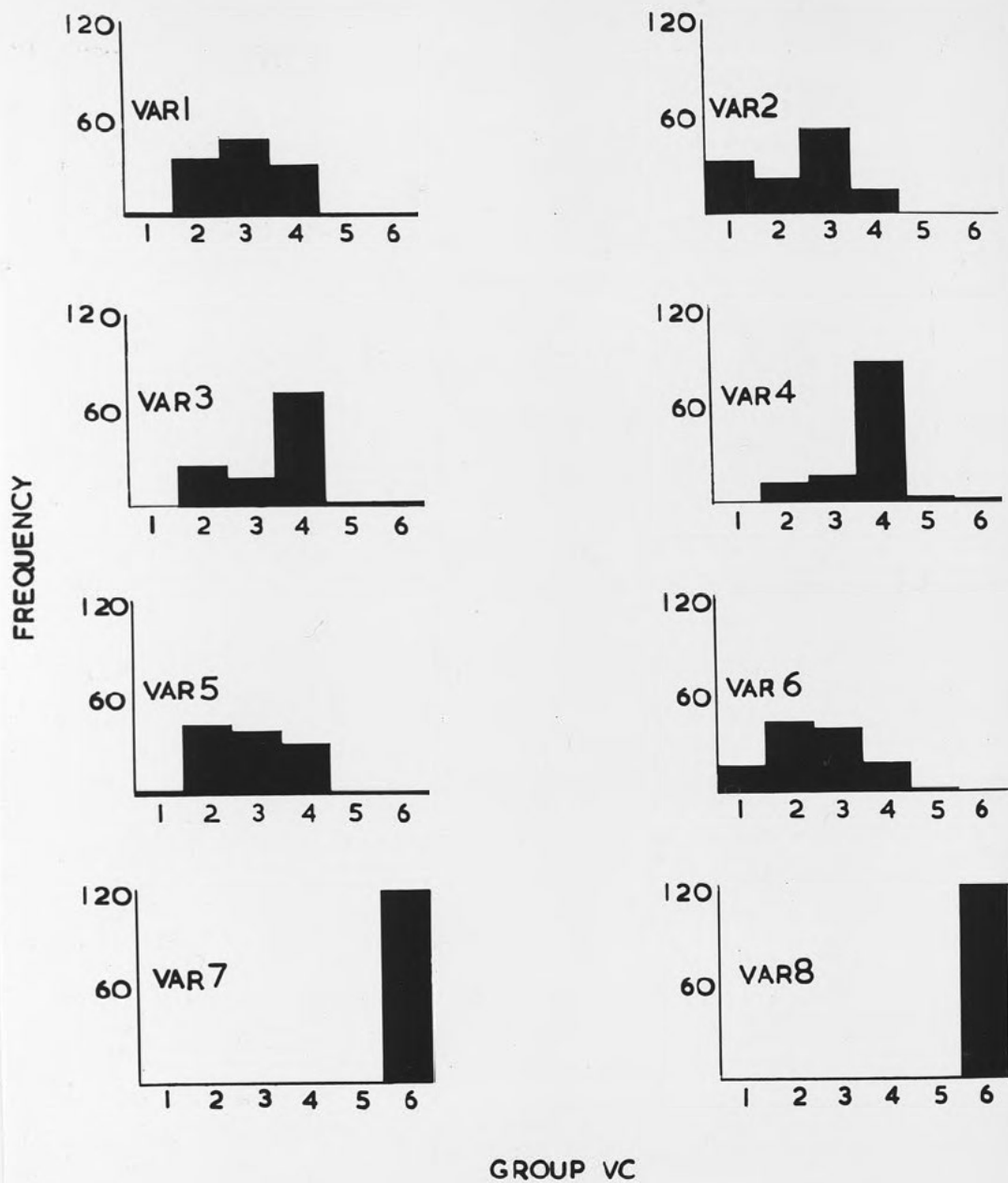


FIGURE 20

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968

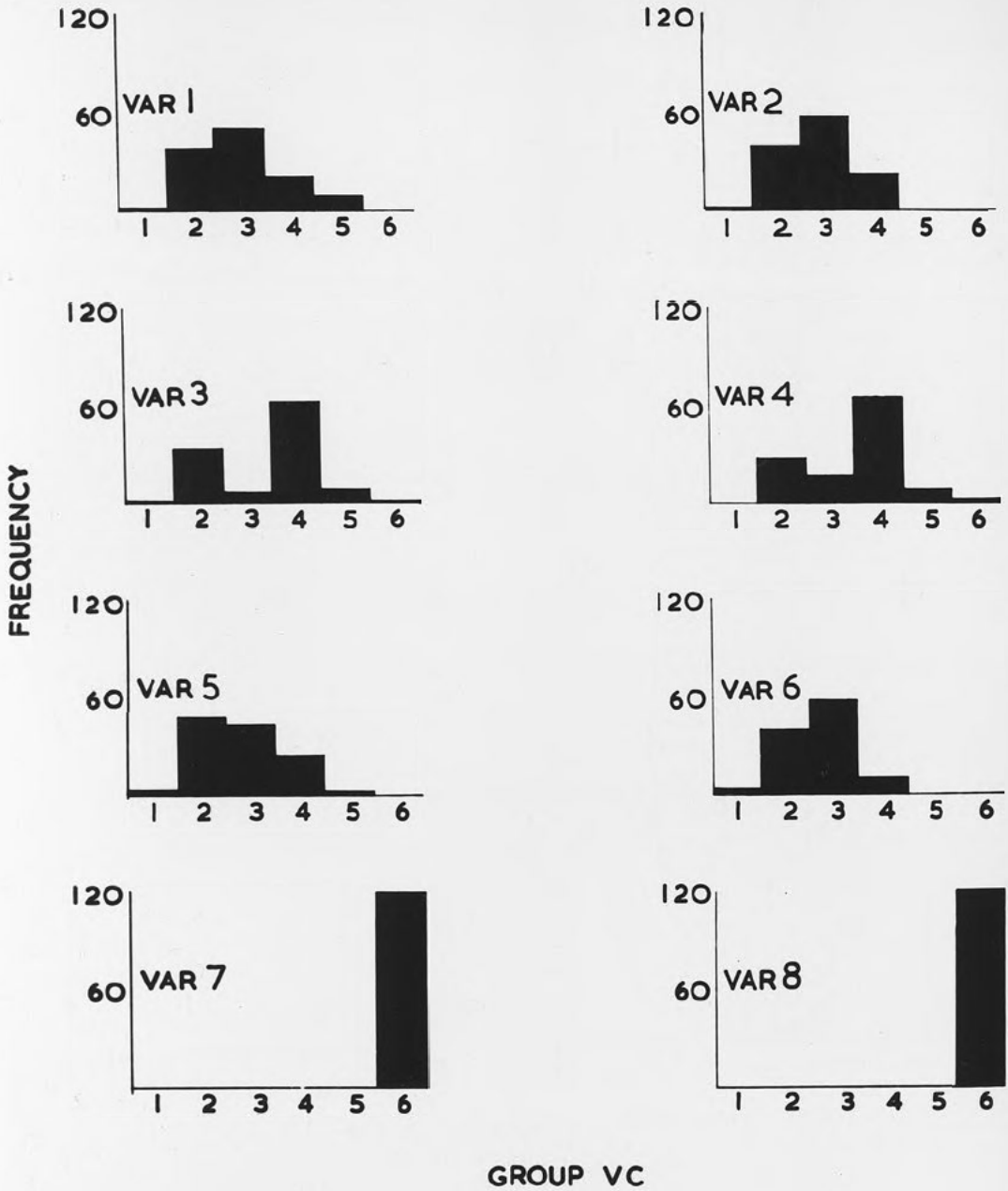


FIGURE 21

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1967

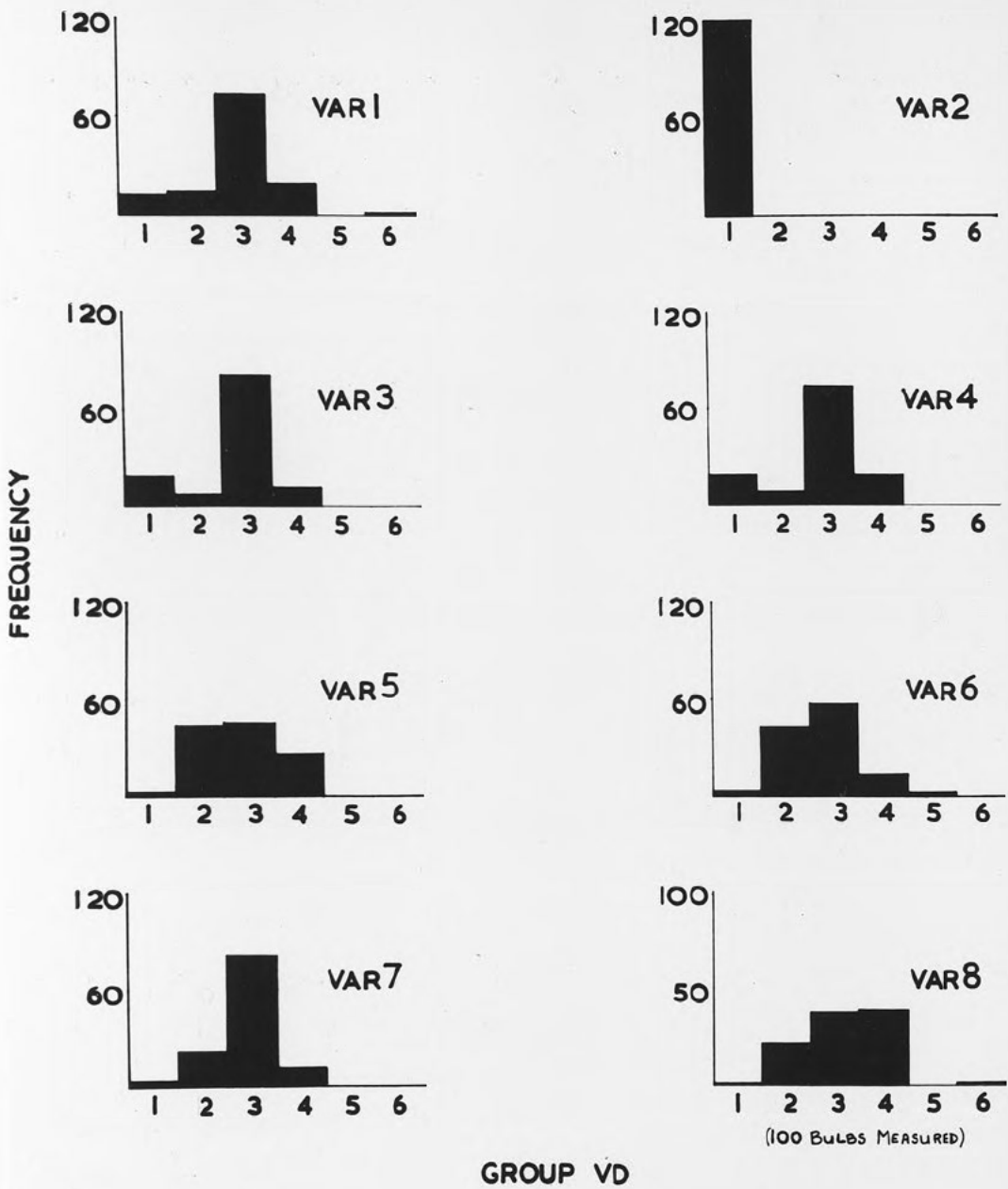


FIGURE 22

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968

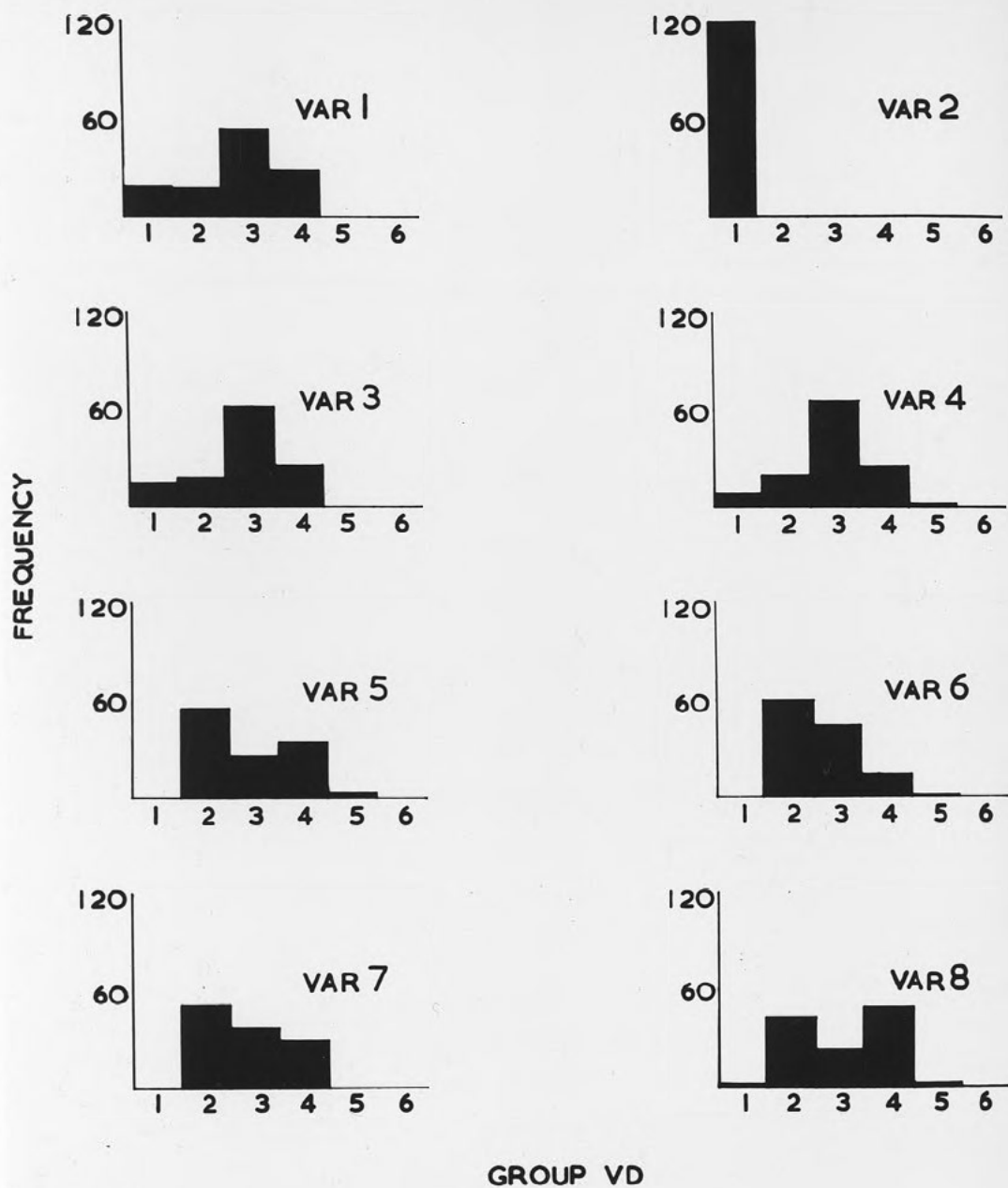
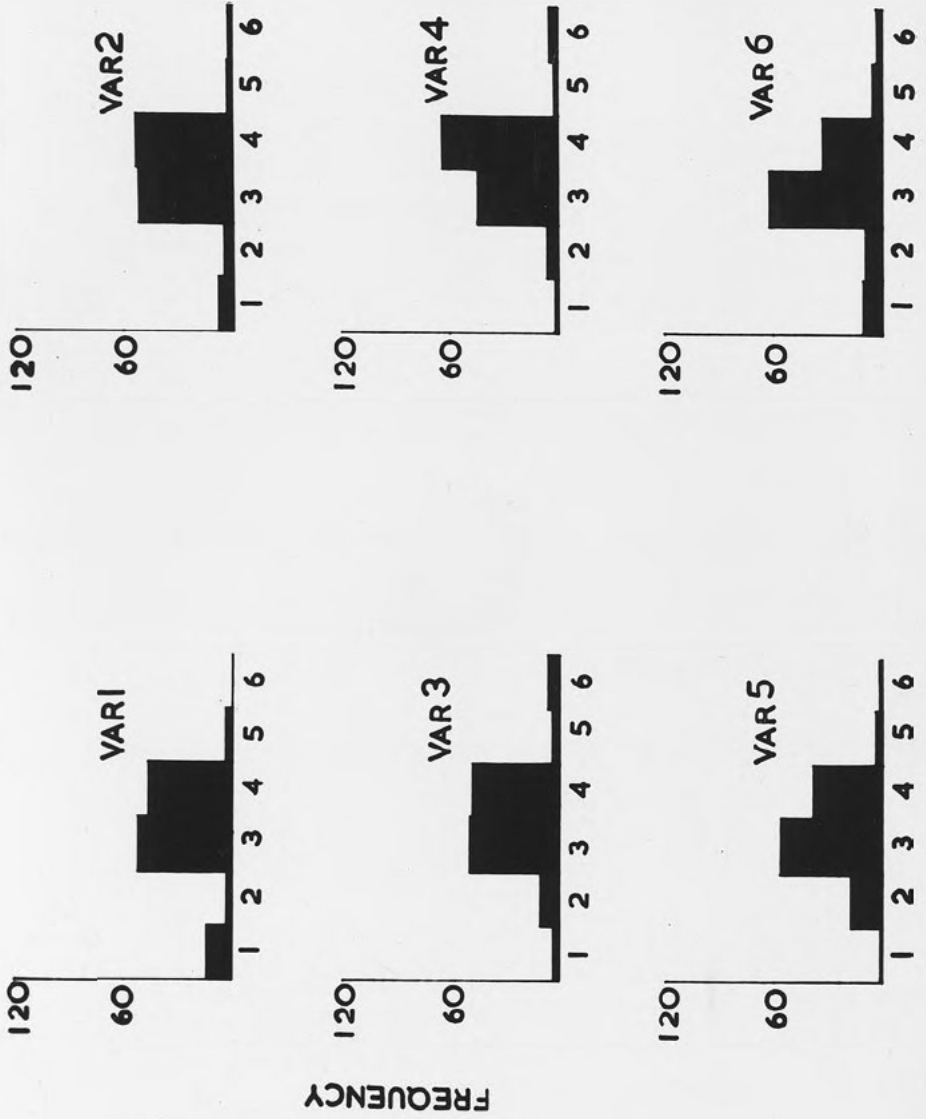


FIGURE 23

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1967



FREQUENCY

GROUP VE

FIGURE 24

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968

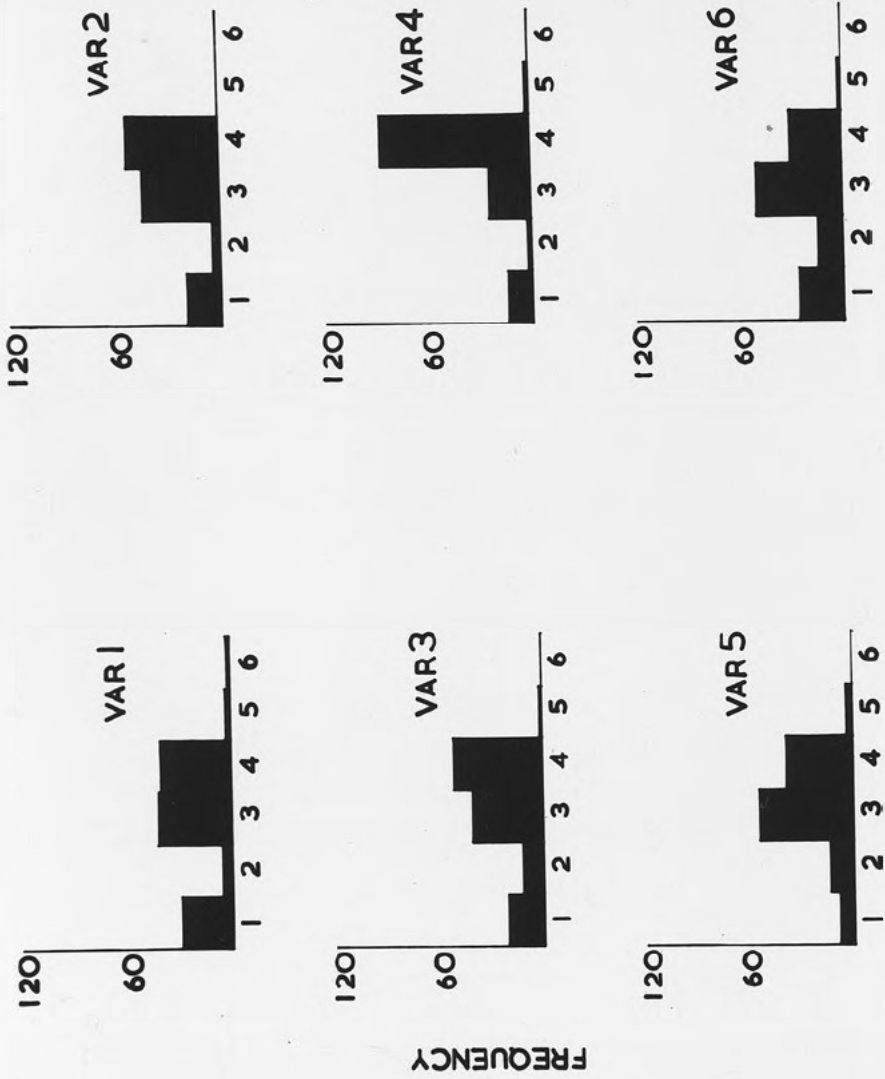
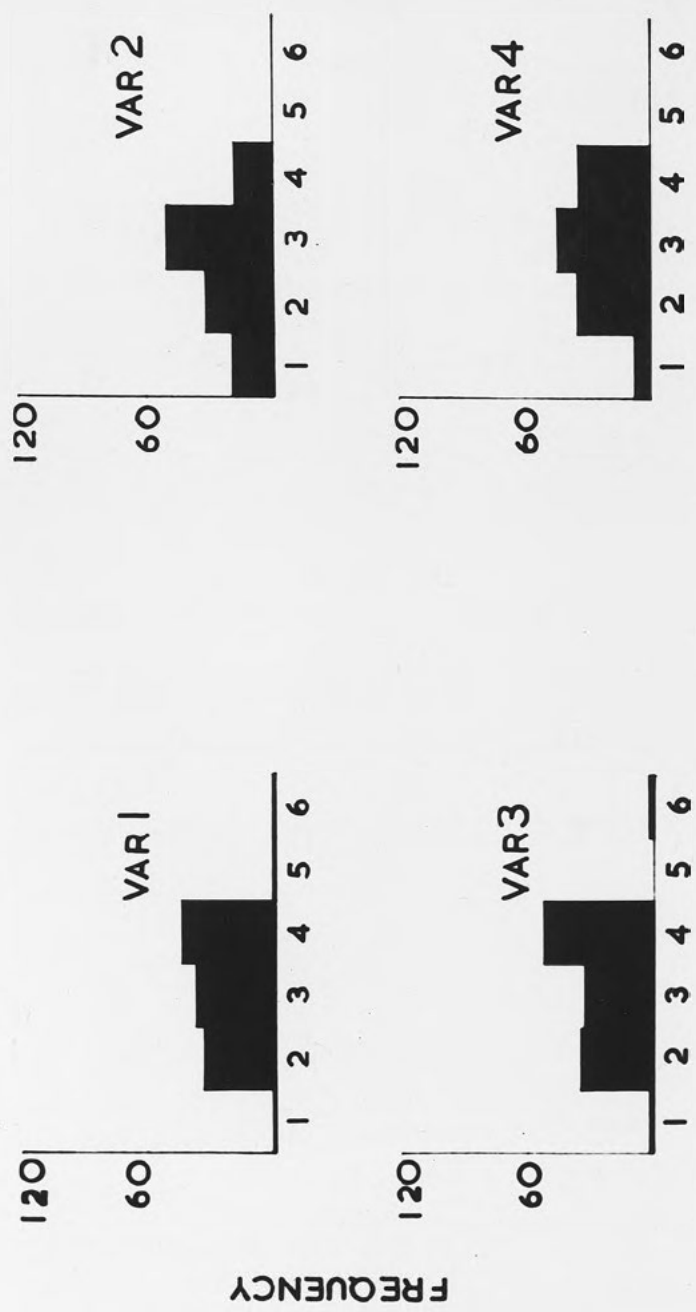


FIGURE 25

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1967



GROUP VF

FIGURE 26

FREQUENCY DISTRIBUTION HISTOGRAMS OF BULB SHAPE 1968

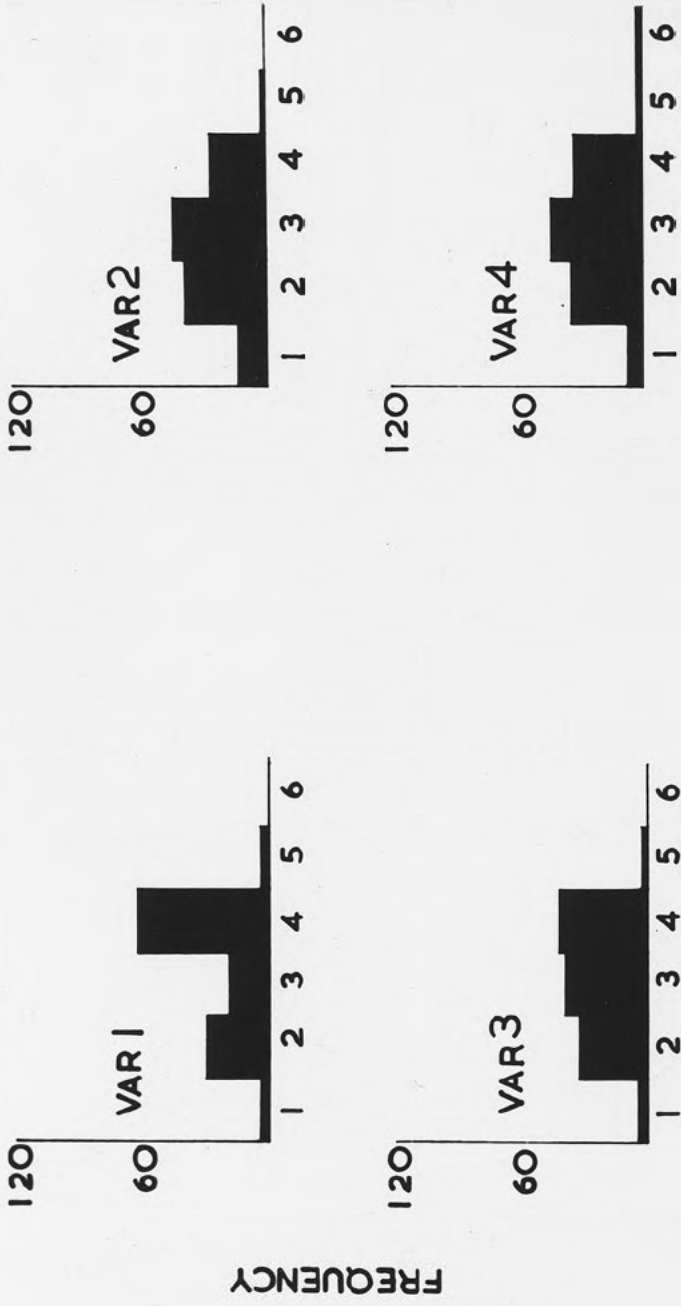


FIGURE 27

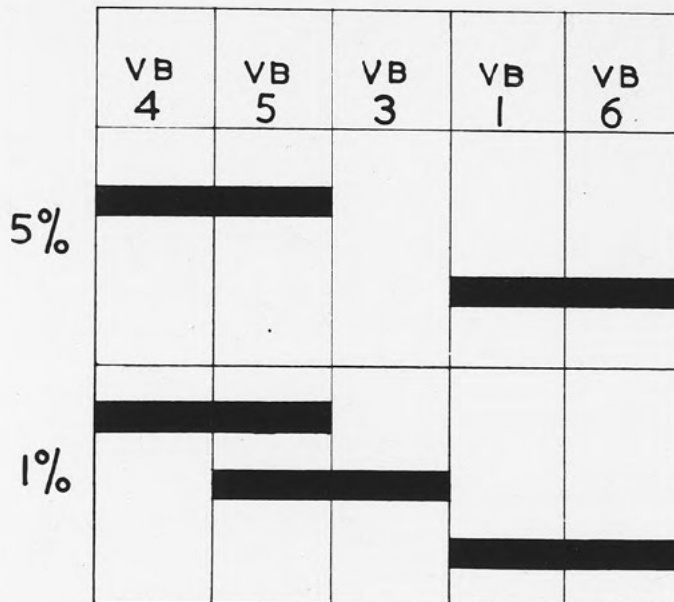
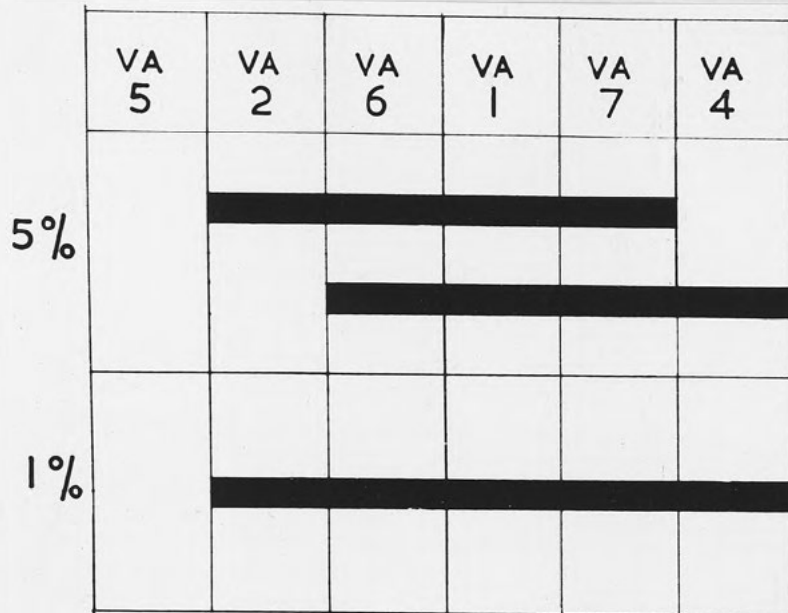
TABLES OF SIGNIFICANT DIFFERENCES BETWEEN MEANS

The presentation of the data in the following manner is similar to that given by Steel and Torrie (1960).

The varieties are represented on the top line by their plot number eg. VA.1 is Early Snowball and two tables are made out for each variety, one at the five per cent, the other at the one per cent level of significance. Figures give results of shape, height, width and height/diameter ratio records.

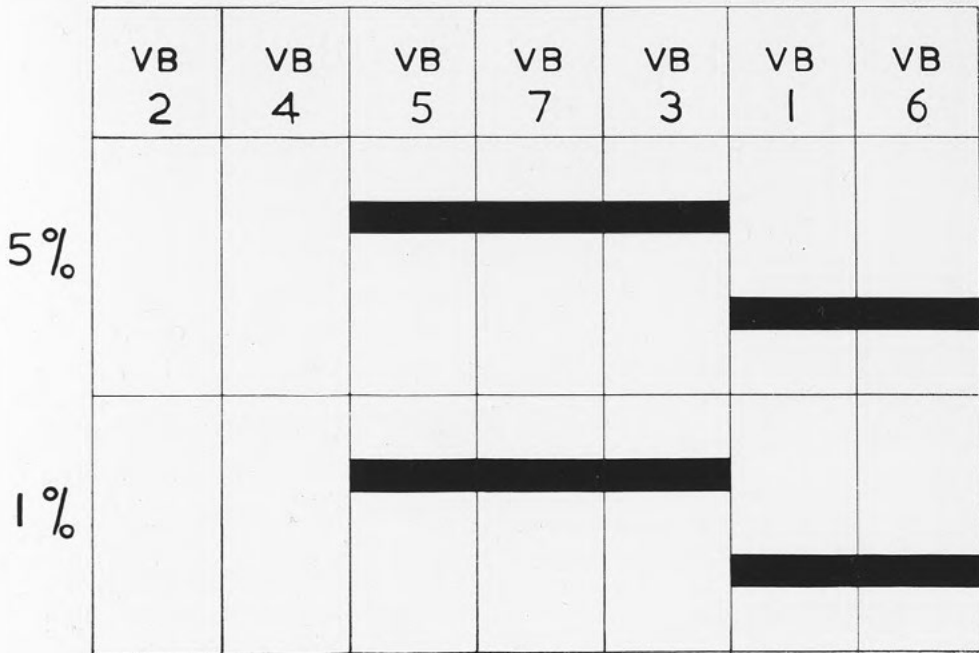
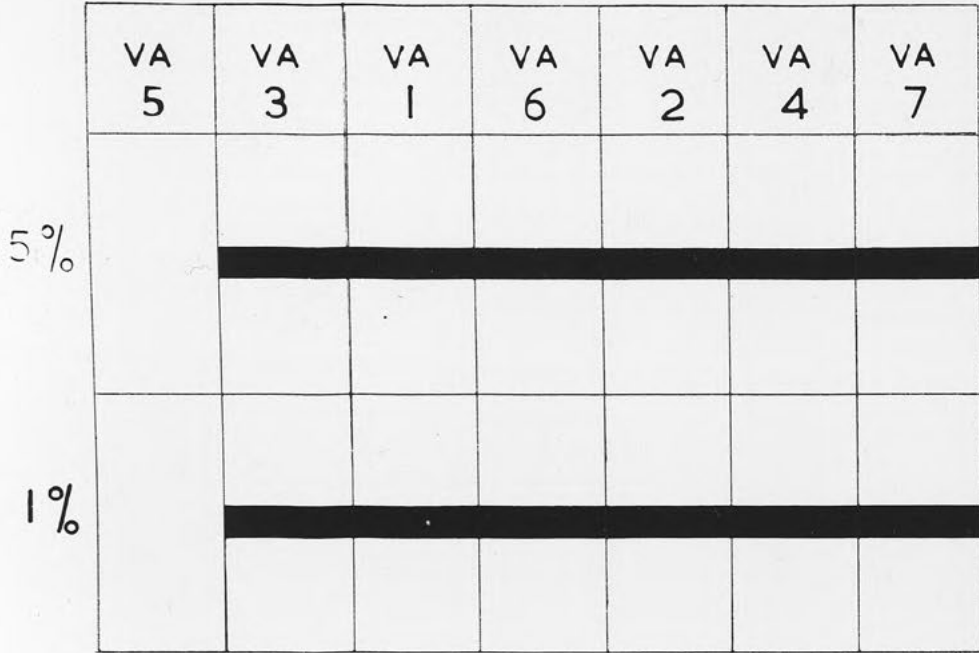
Any two means not underscored by the same line are significantly different. Any two means underscored by the same line are not significantly different.

Actual values of the means of each variety for each character analysed can be found by reference to the Appendix (page 85) where tables of analysis of variance and variety means are given.



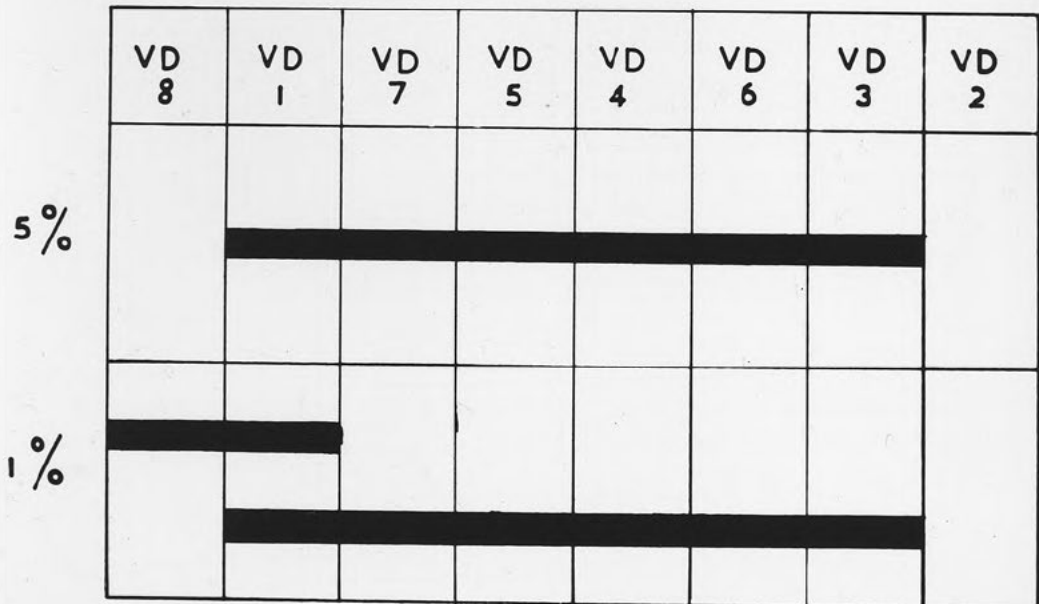
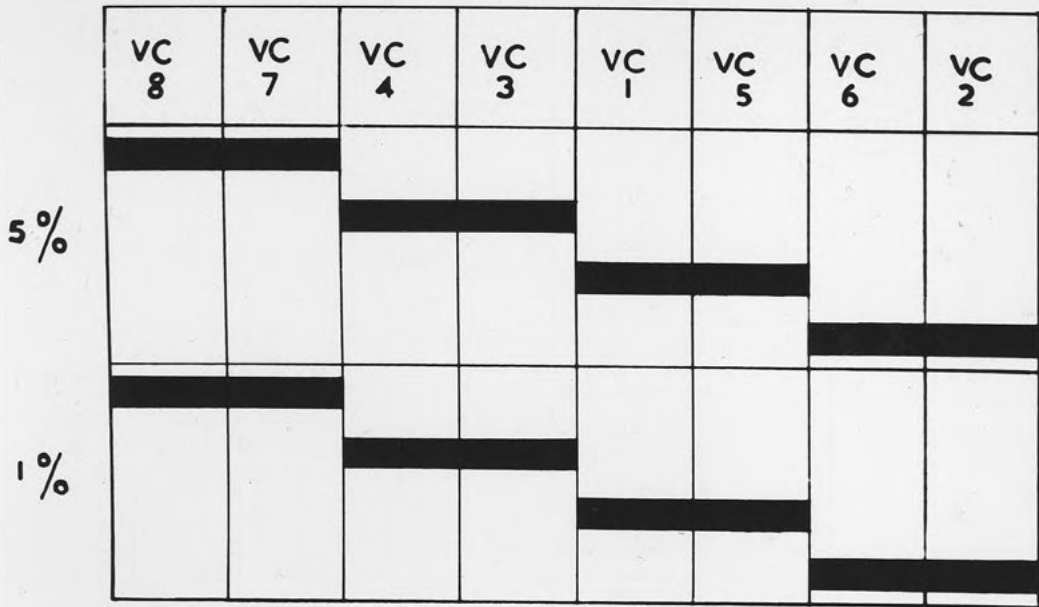
BULB SHAPE 1967

FIGURE 28



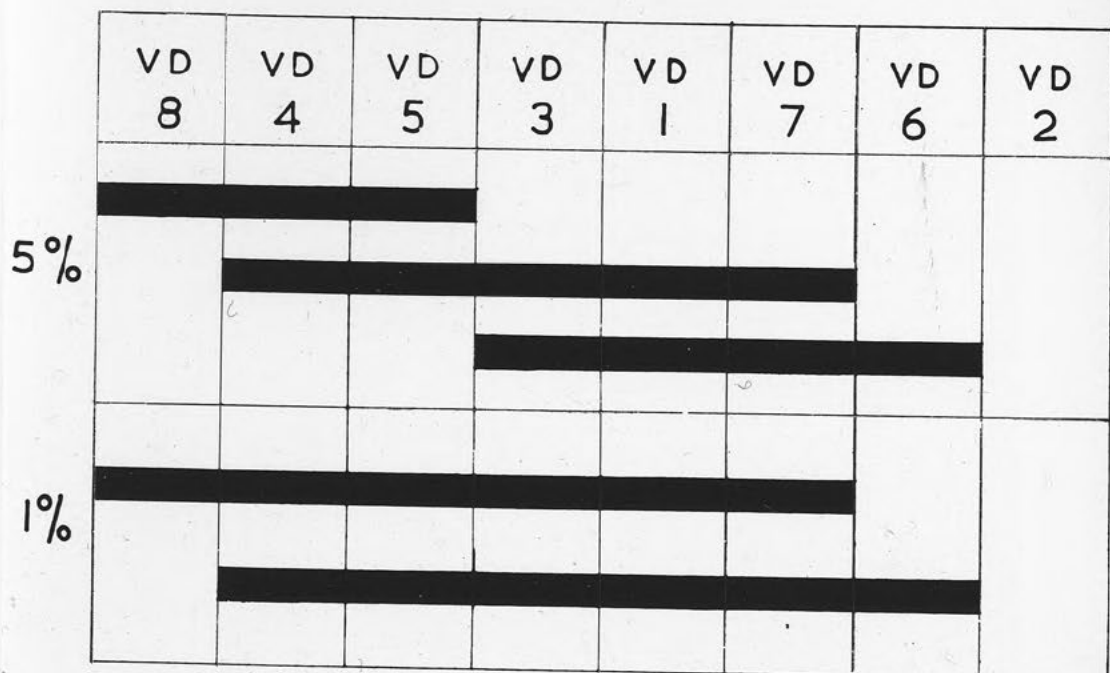
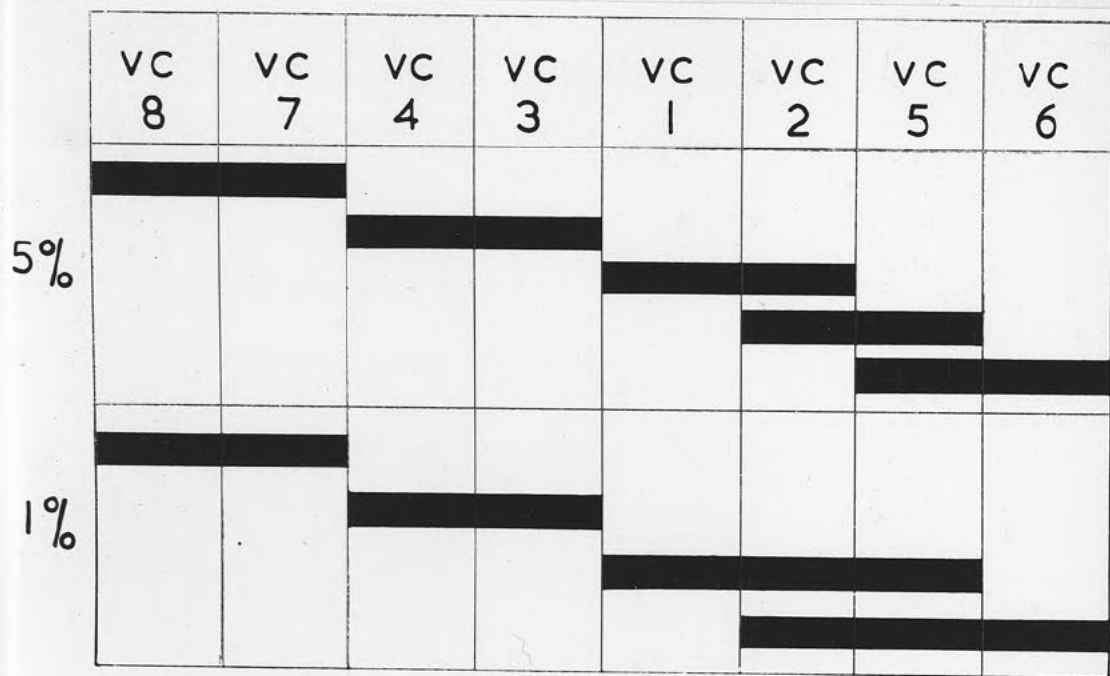
BULB SHAPE 1968

FIGURE 29



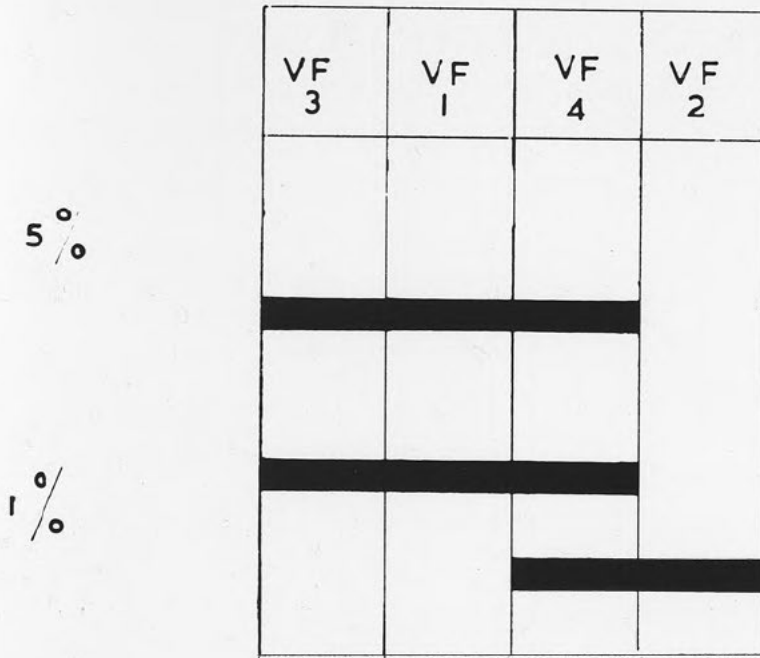
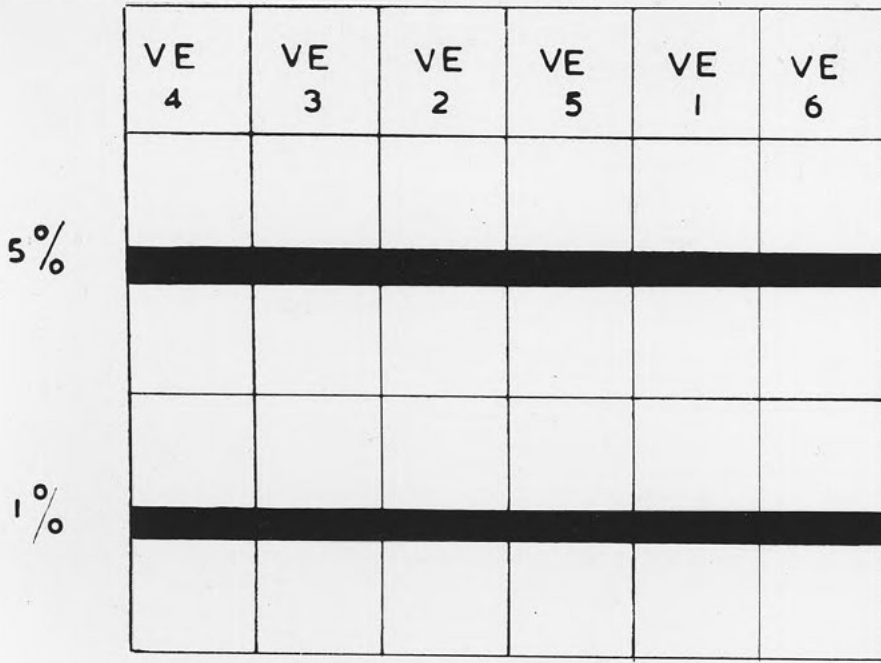
BULB SHAPE 1967

FIGURE 30



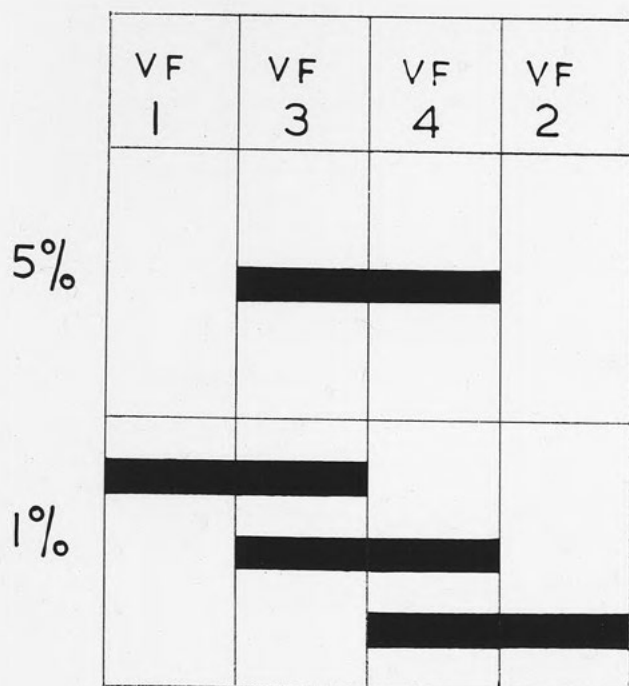
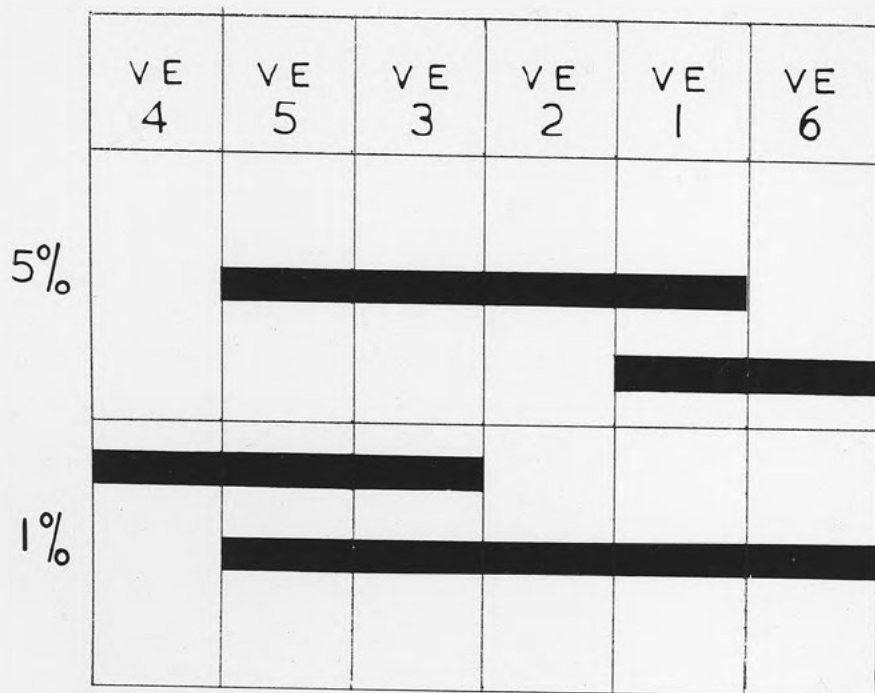
BULB SHAPE 1968

FIGURE 31



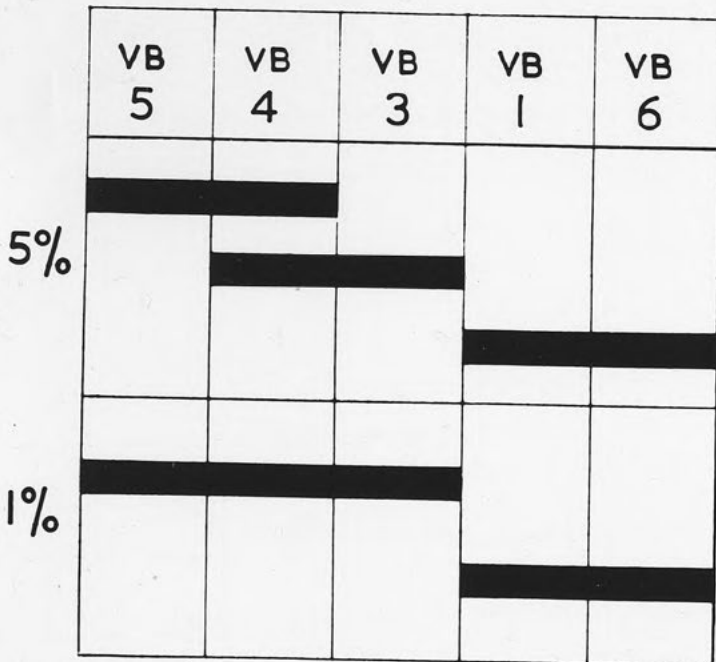
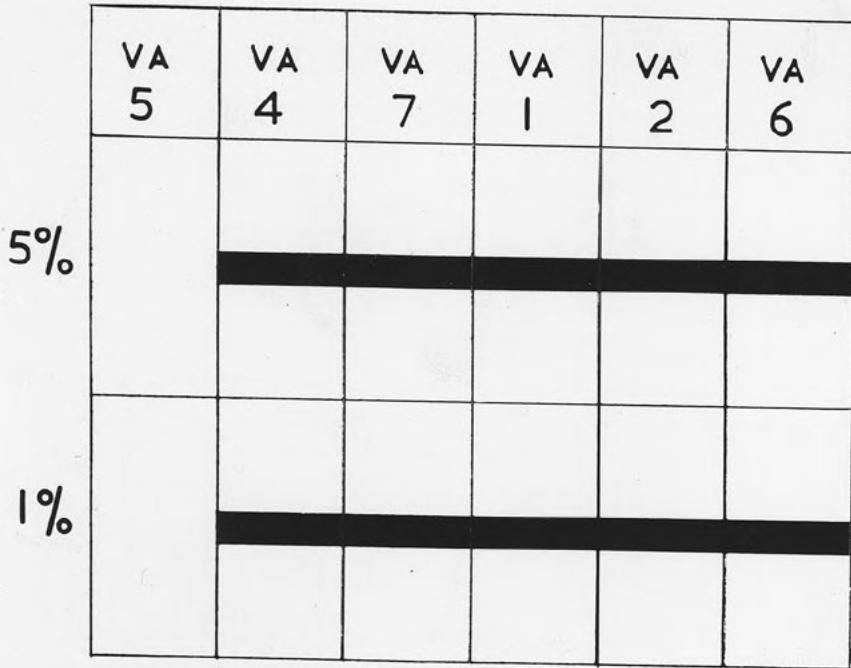
BULB SHAPE 1967

FIGURE 32



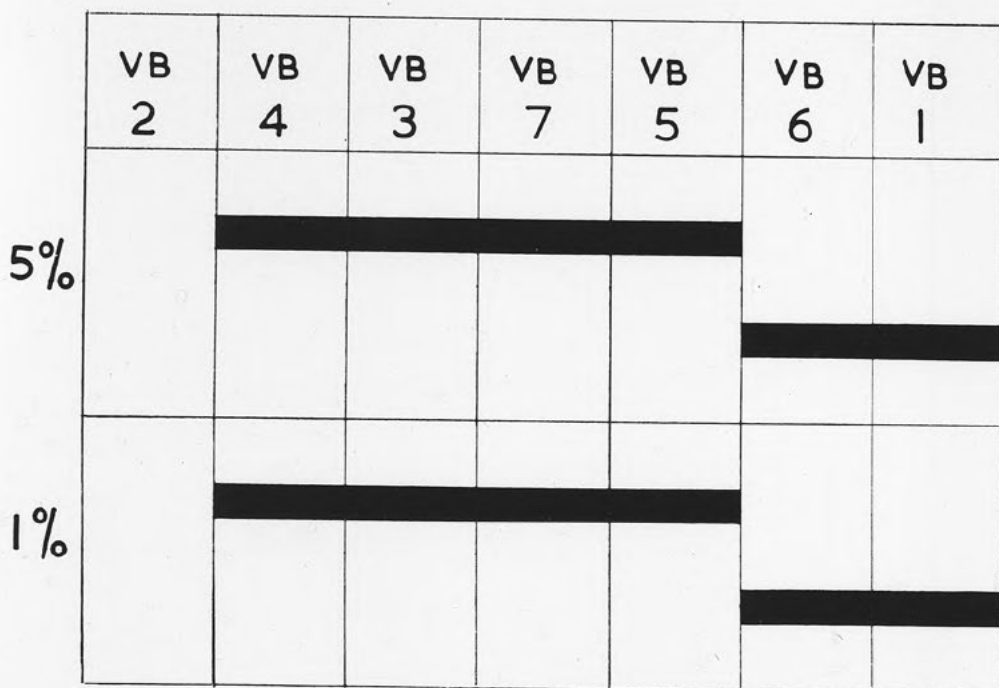
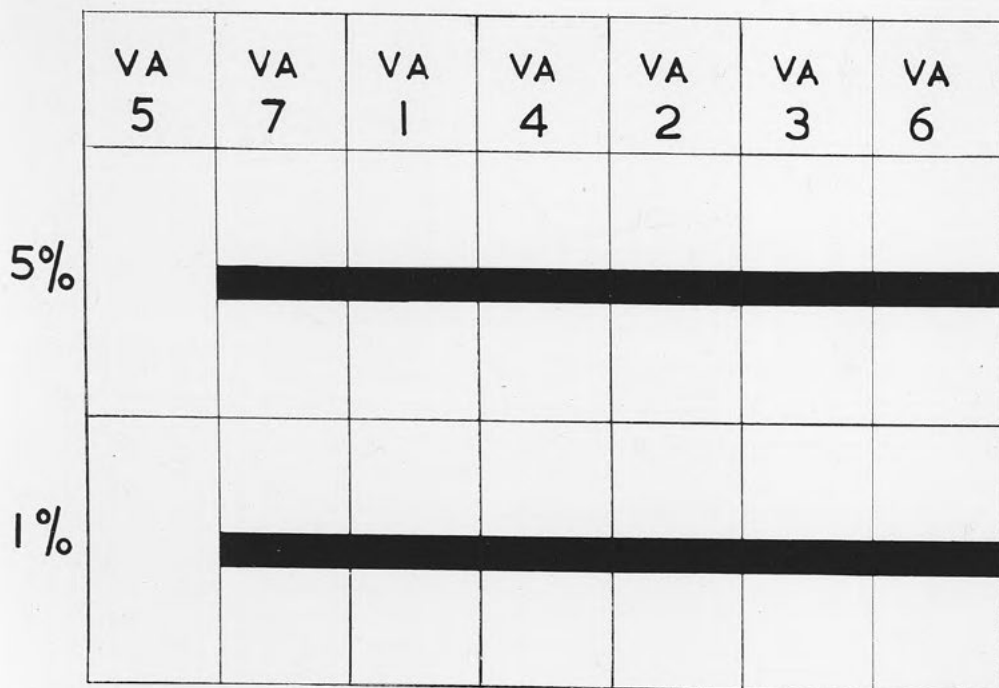
BULB SHAPE 1968

FIGURE 33



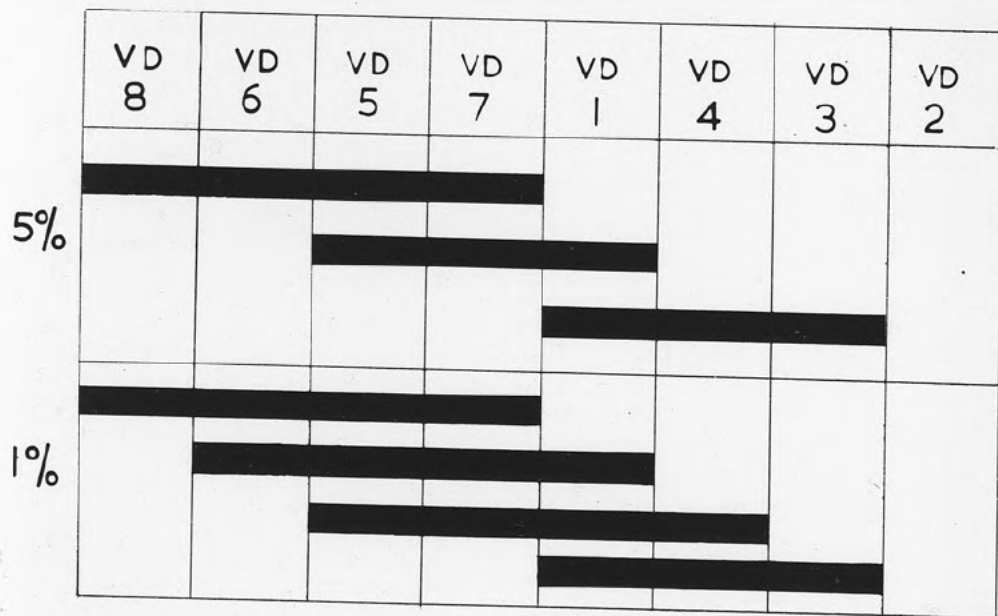
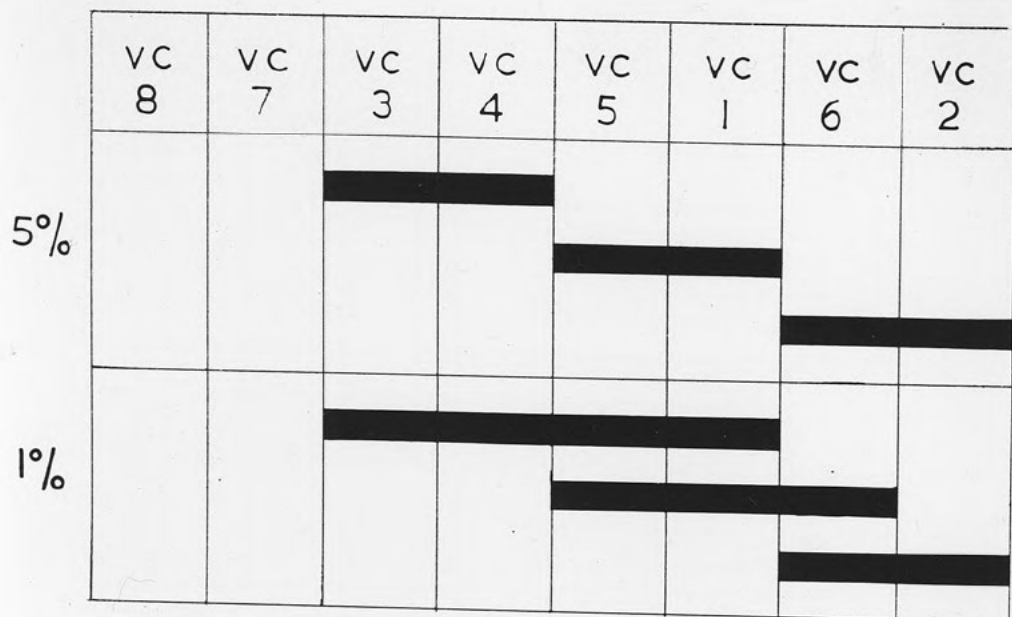
BULB HEIGHT 1967

FIGURE 34



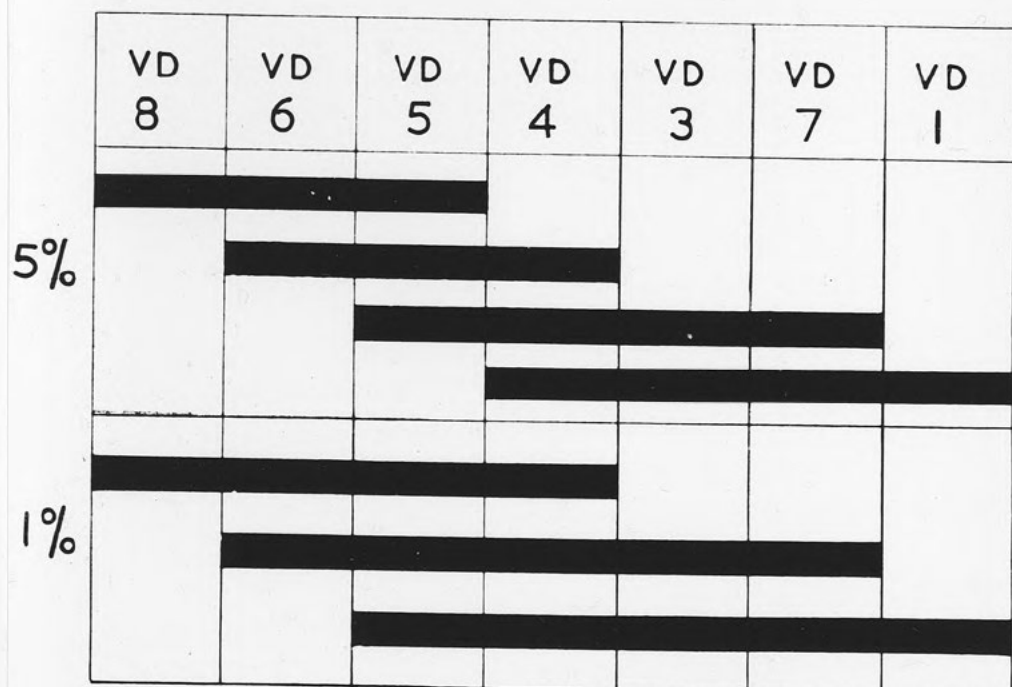
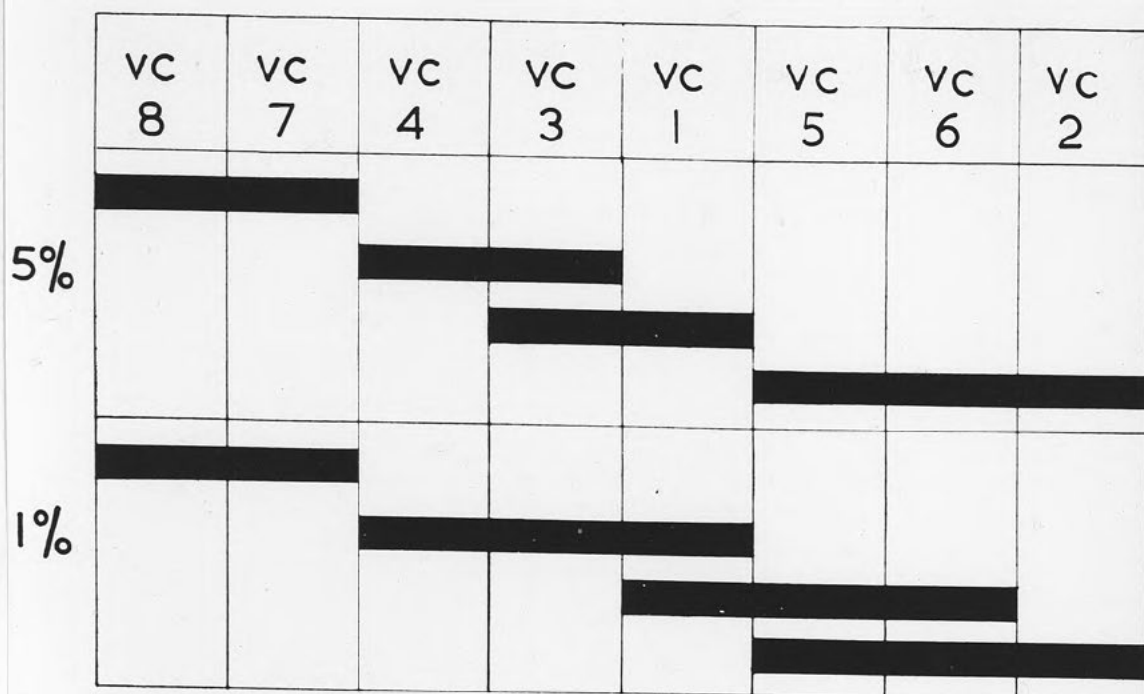
BULB HEIGHT 1968

FIGURE 35



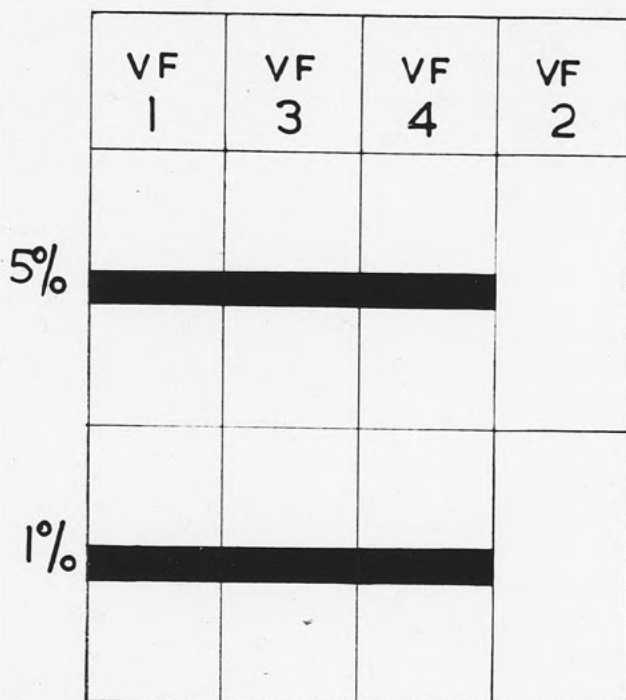
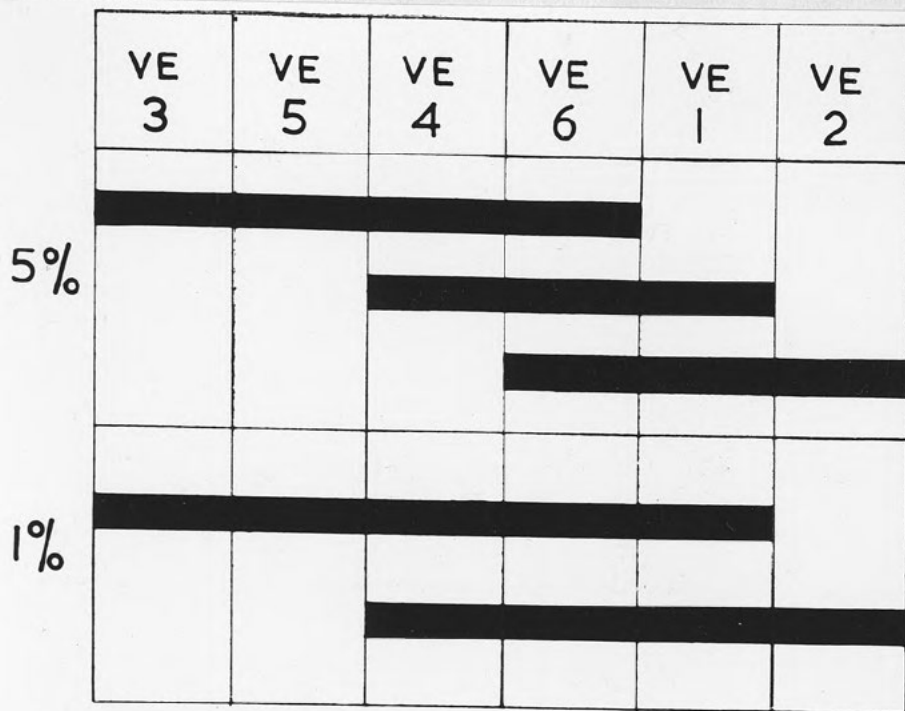
BULB HEIGHT 1967

FIGURE 36



BULB HEIGHT 1968

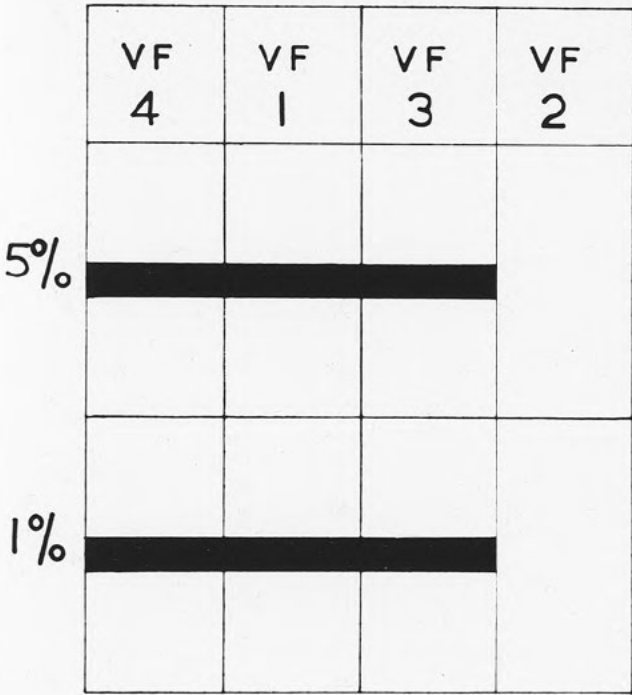
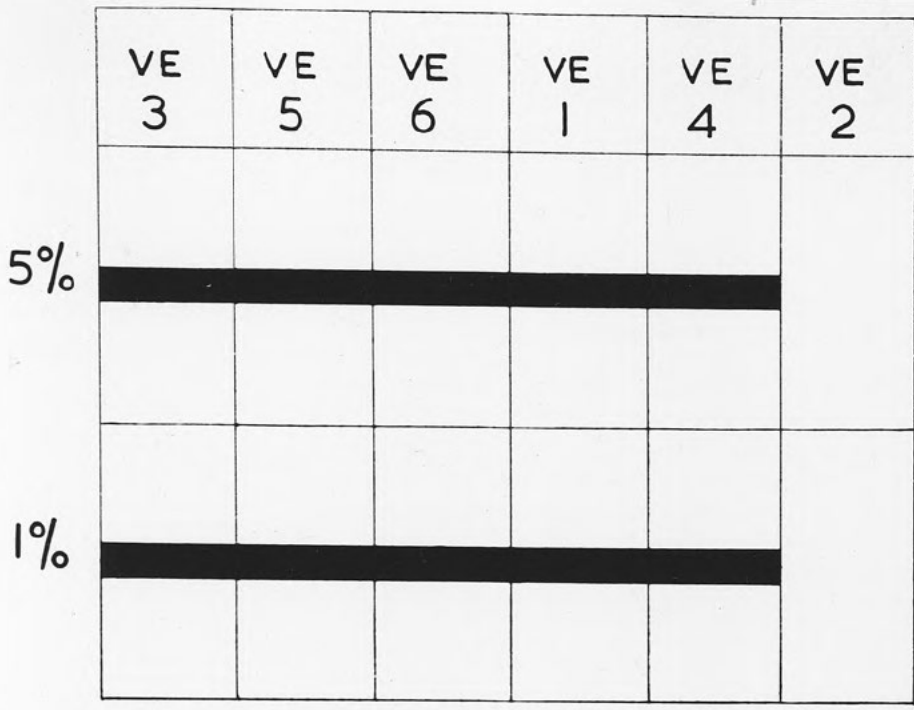
FIGURE 37



BULB HEIGHT 1967

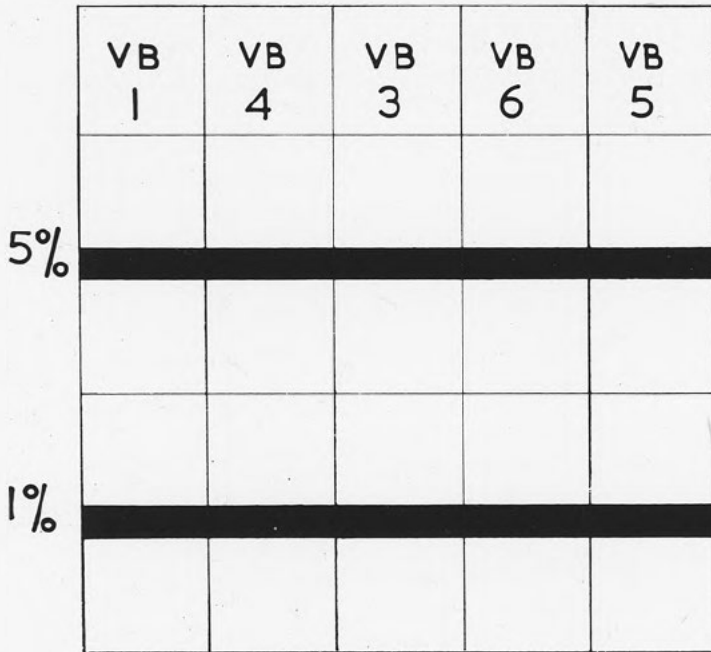
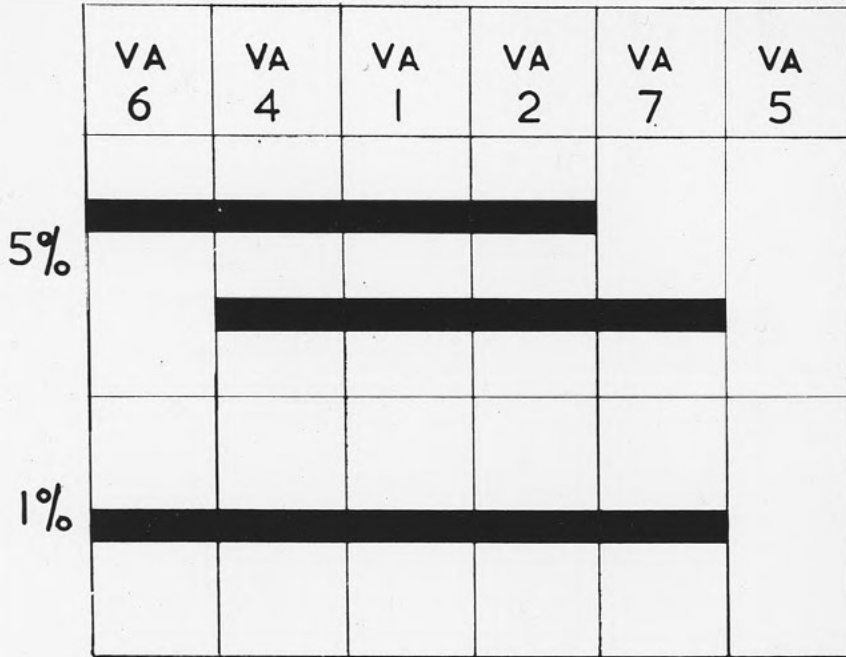
FIGURE 38





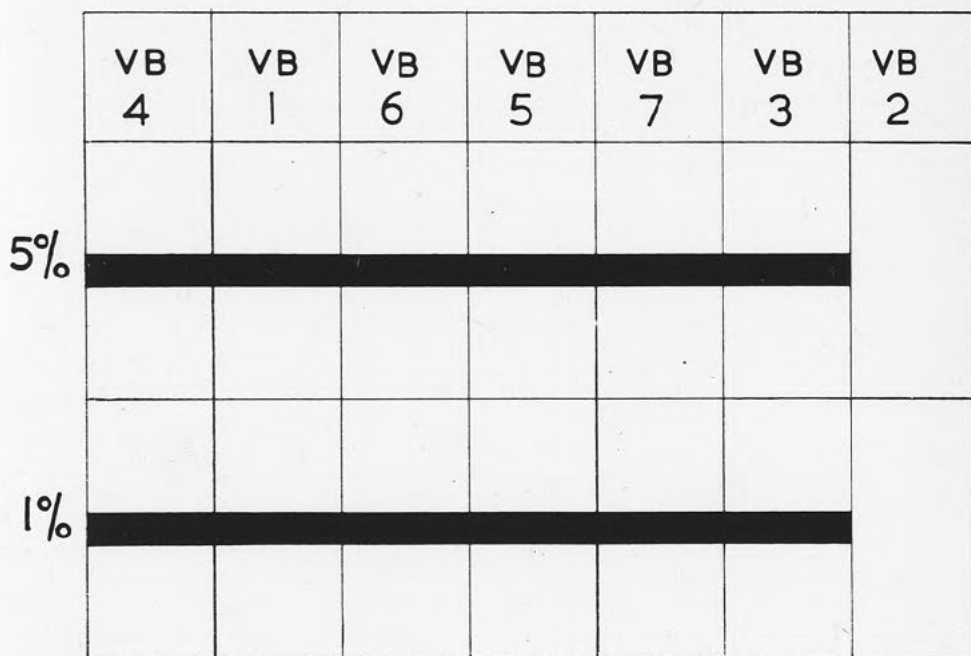
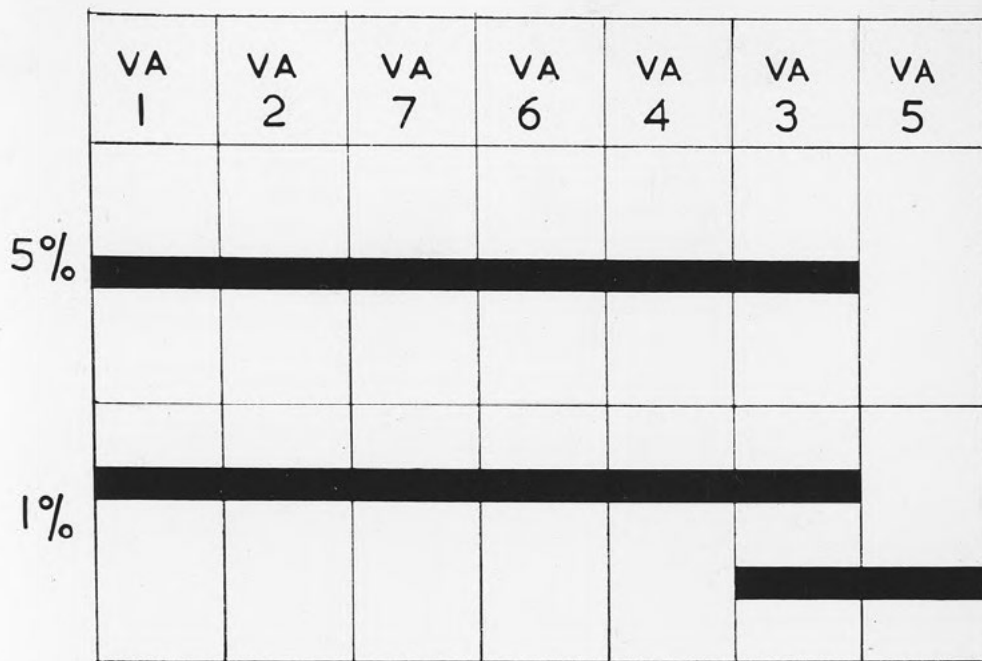
BULB HEIGHT 1968

FIGURE 39



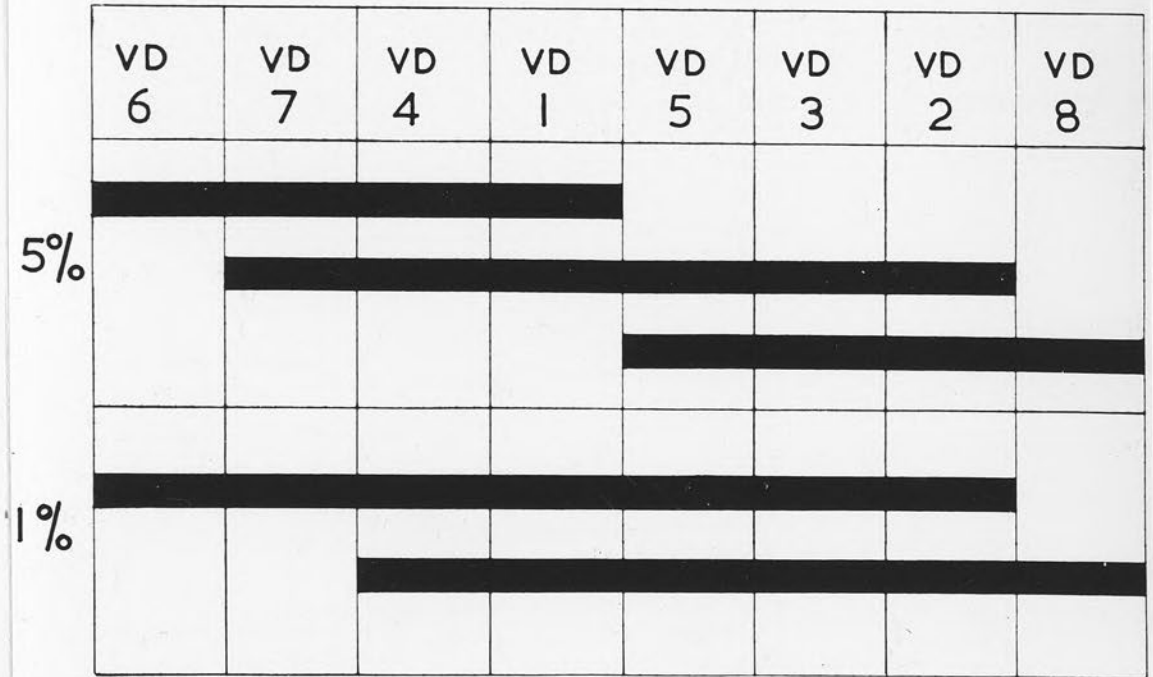
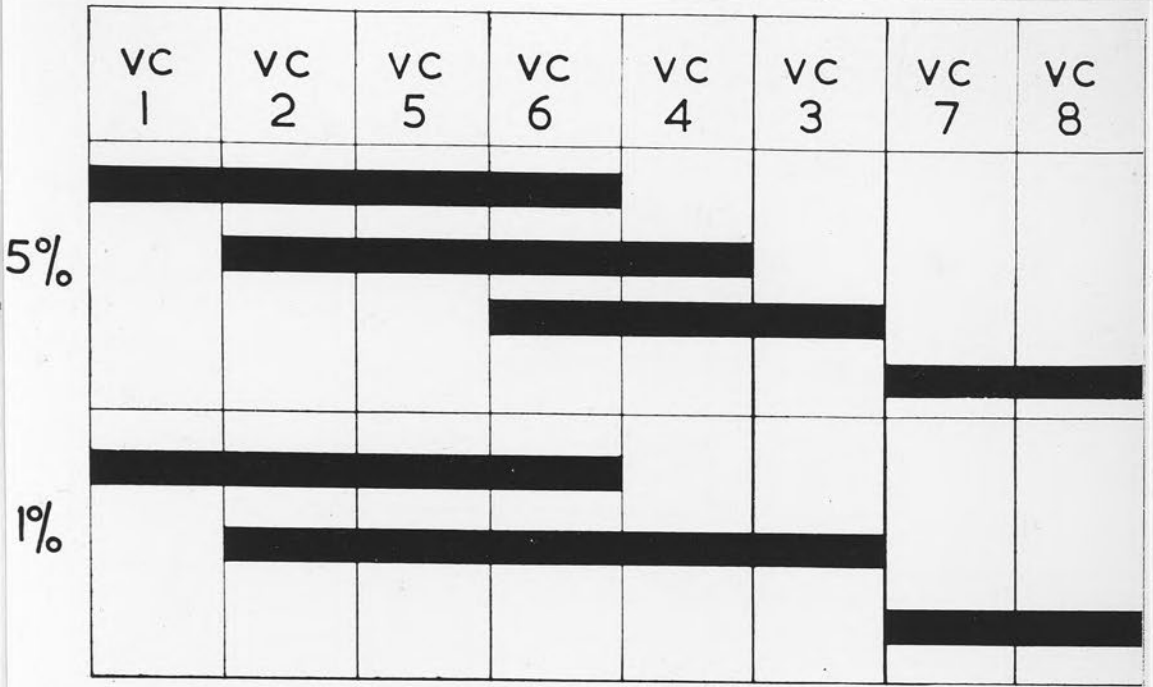
BULB DIAMETER 1967

FIGURE 40



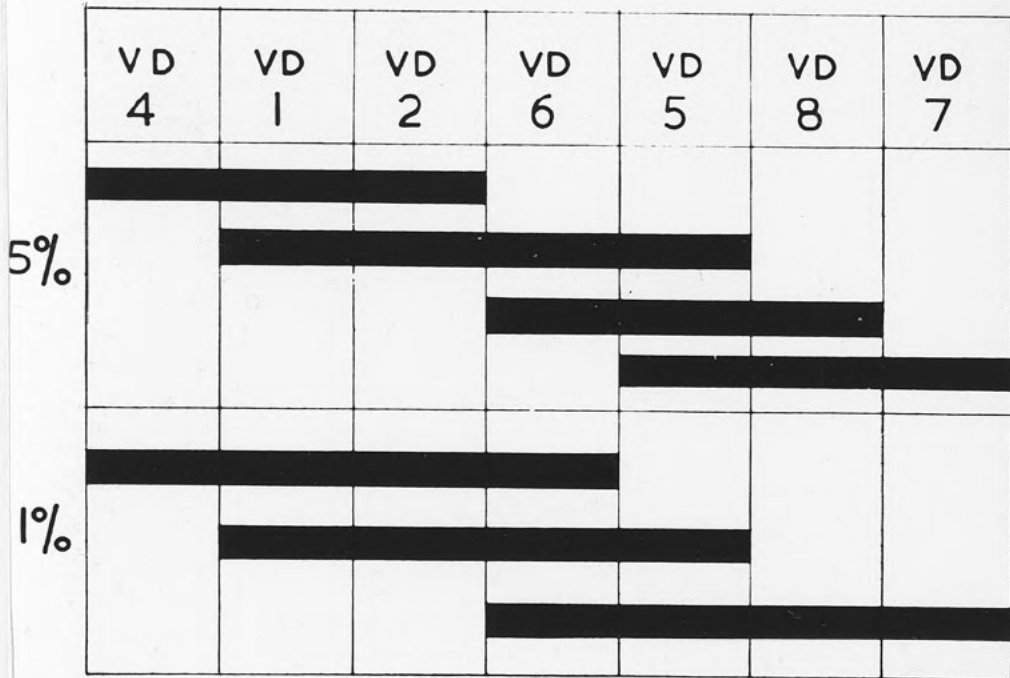
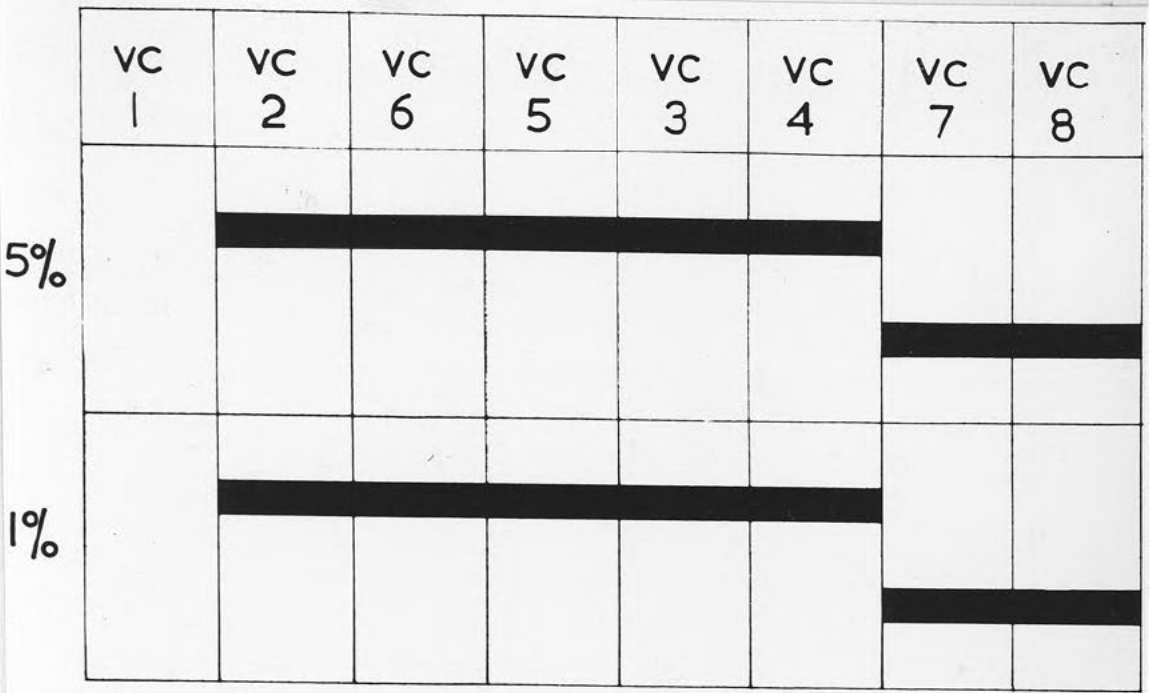
BULB DIAMETER 1968

FIGURE 41



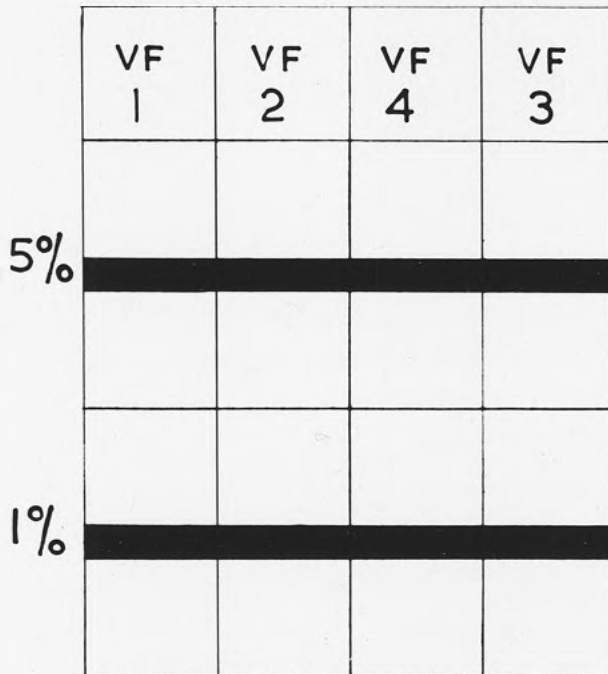
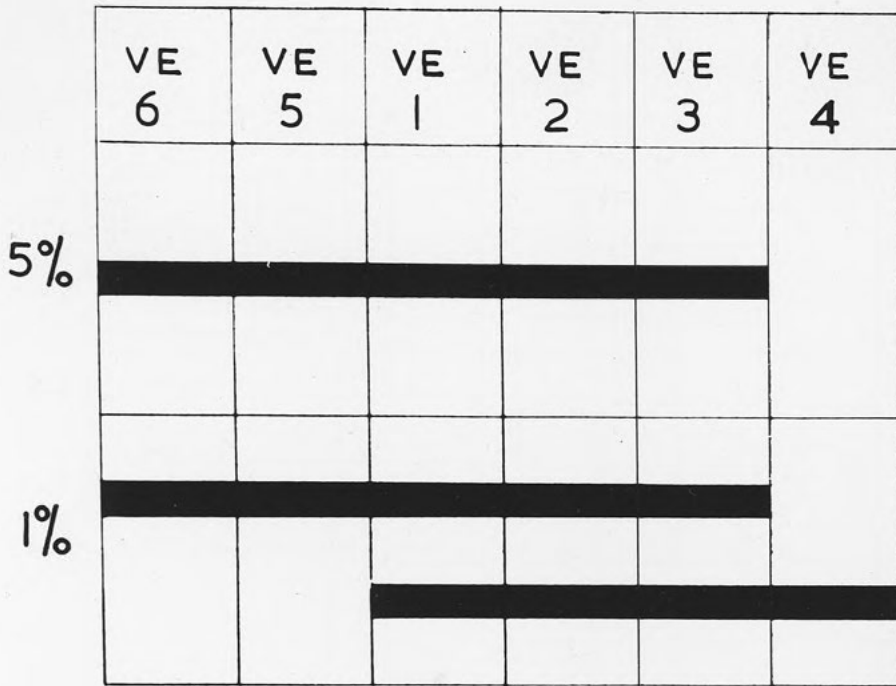
BULB DIAMETER 1967

FIGURE 42



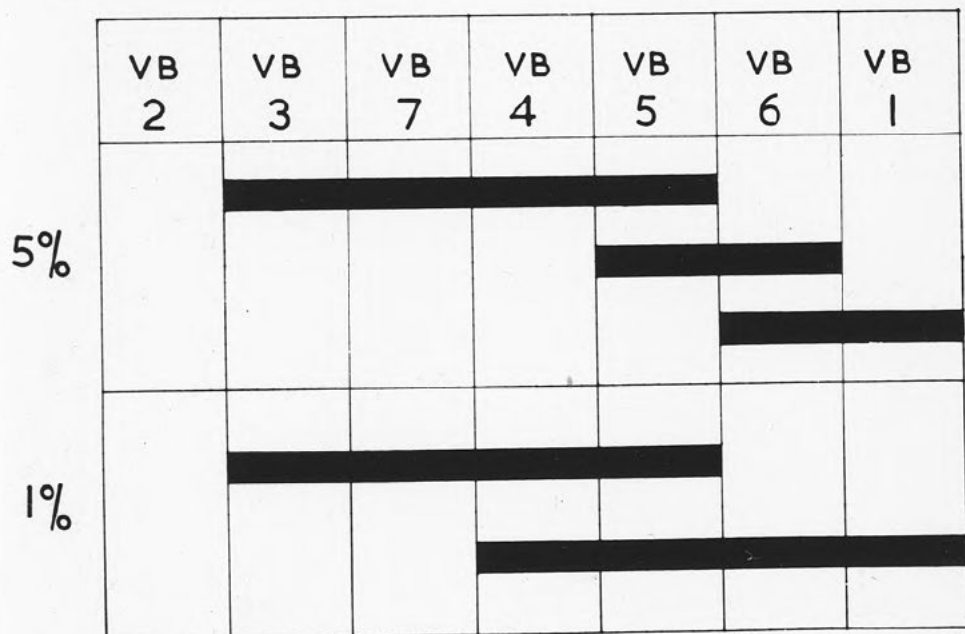
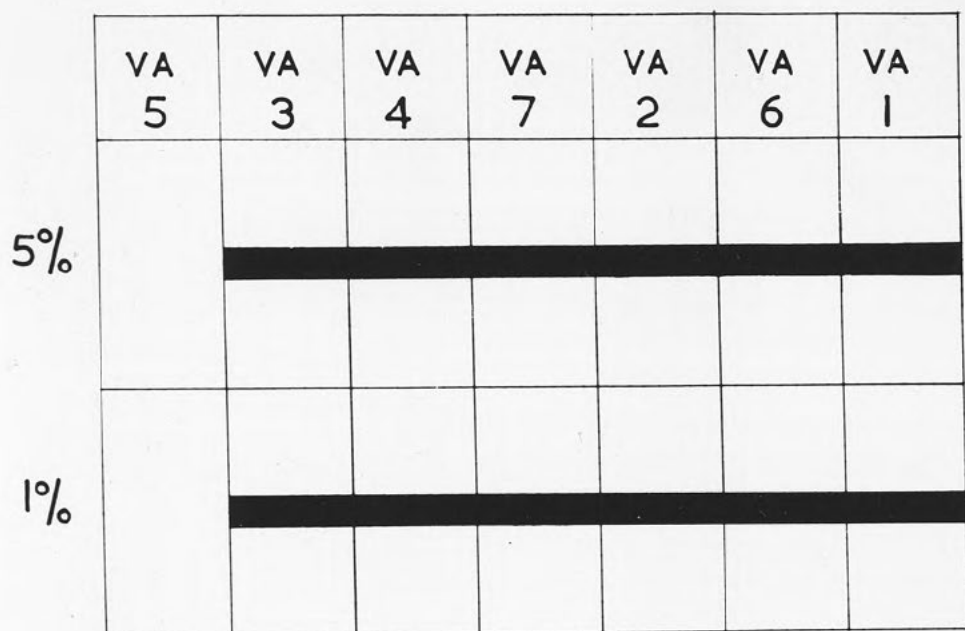
BULB DIAMETER 1968

FIGURE 43



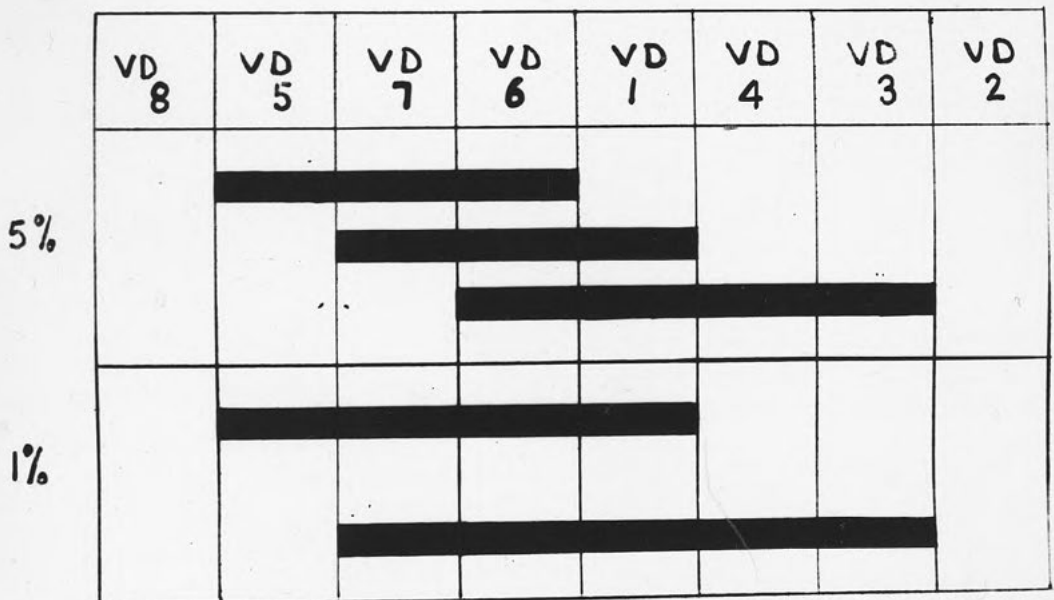
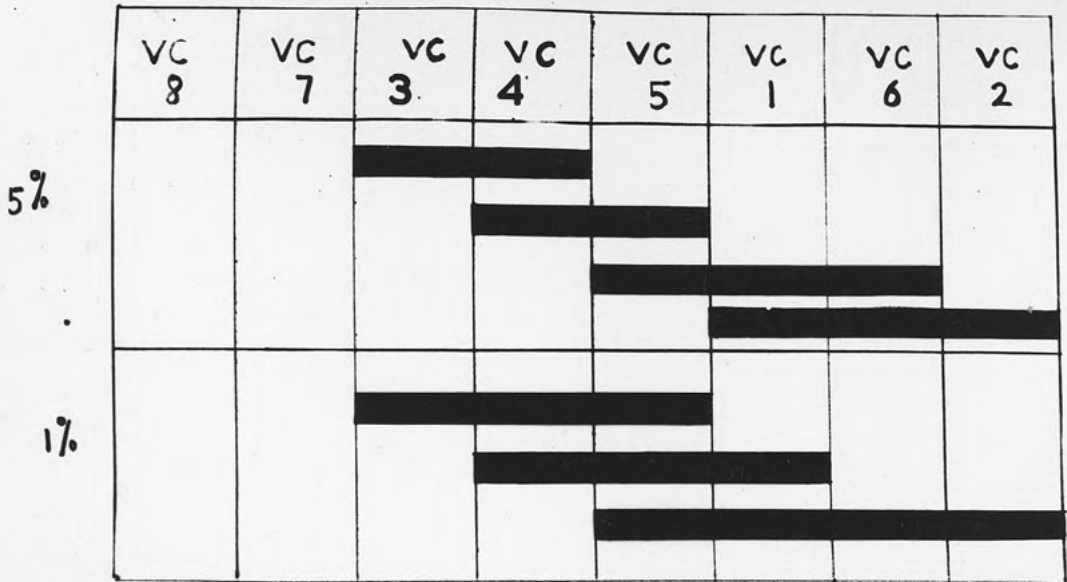
BULB DIAMETER 1967

FIGURE 44



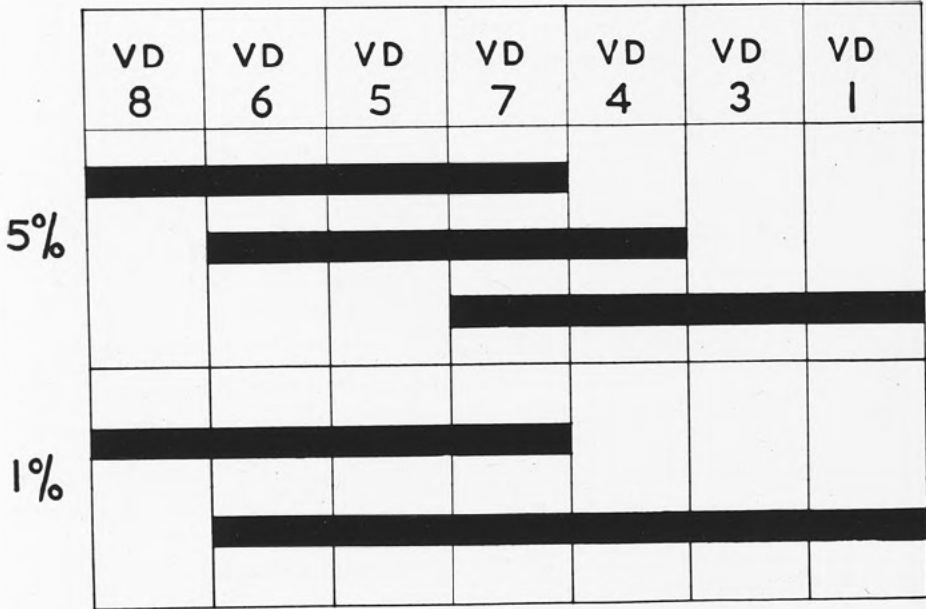
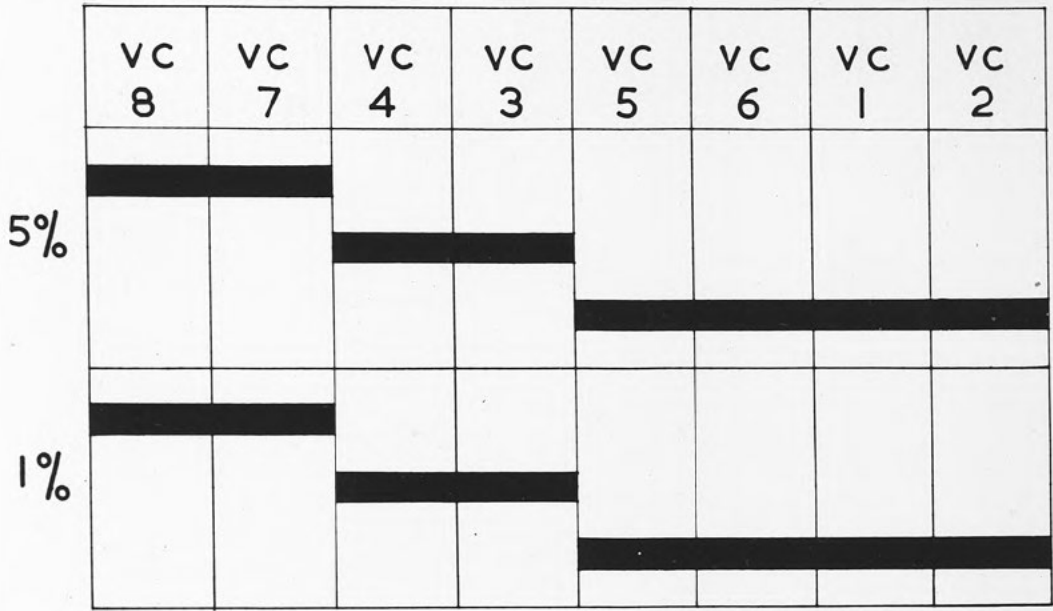
HEIGHT DIAMETER RATIO 1968

FIGURE 47



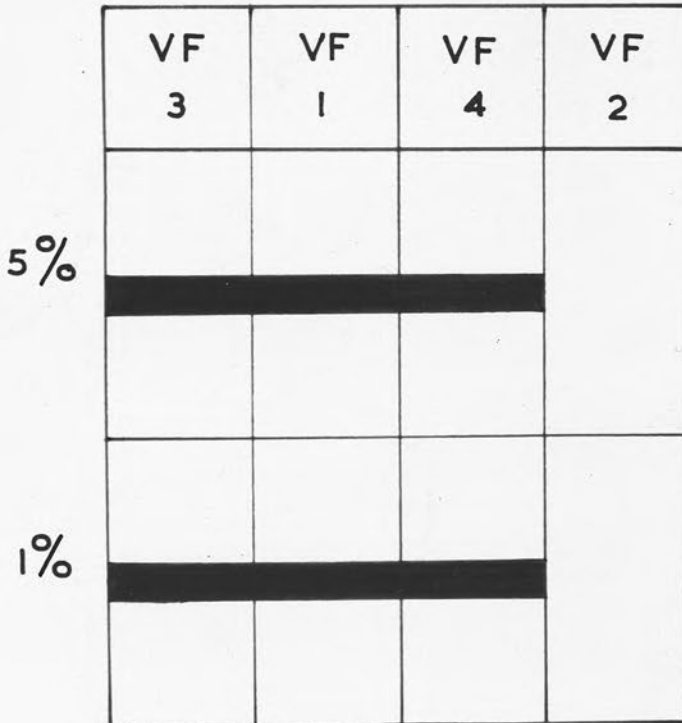
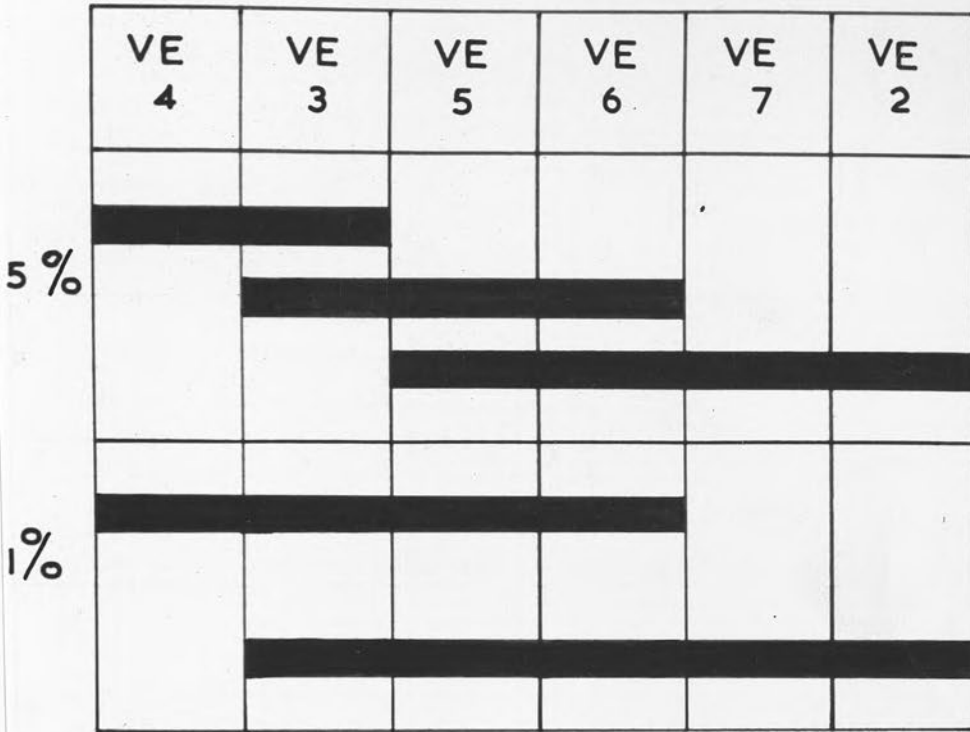
HEIGHT DIAMETER RATIO. 1967

FIGURE 48



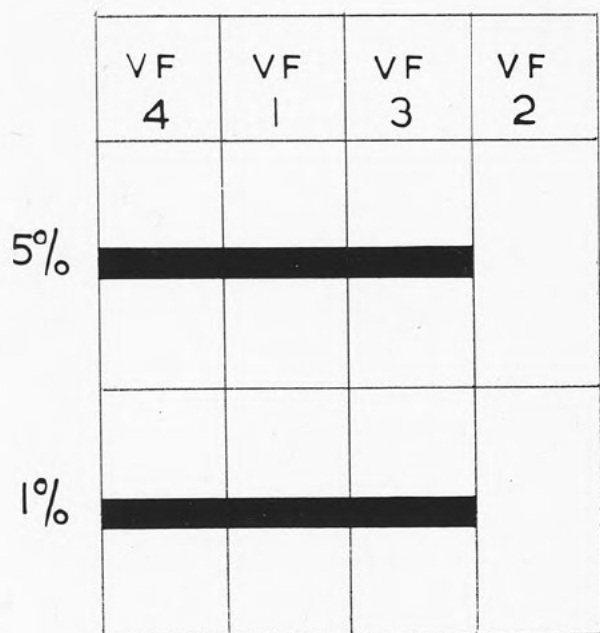
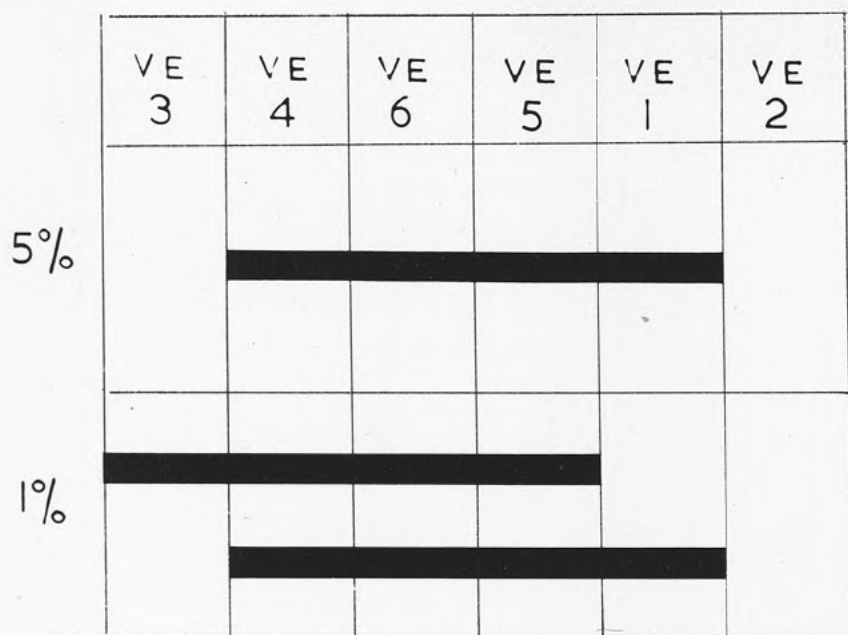
HEIGHT DIAMETER RATIO 1968

FIGURE 49



HEIGHT: DIAMETER RATIO. 1967.

FIGURE 50



HEIGHT DIAMETER RATIO 1968

FIGURE 51

ANALYSIS OF SINGLE CHARACTERS"Shape"

In general the results over the two years show a fair degree of consistency and although some variation from year to year does exist, this can be put down to environmental effects. From the analysis of variance diagrams (Figures 28 to 33) the following conclusions can be made, using shape as the sole character.

Group VA - (Figures 28 and 29)

Results indicate that this group can be sub-divided into two:-

1. Variety 5
2. Varieties 1,2,3,4,6 and 7

These results are confirmed at both the five and one per cent levels of significance. The placing of Variety 3 in sub-group 2, is based on one year's results, as due to excessive "bolting" in 1967 no recordings were taken.

Group VB - (Figures 28 and 29)

This group can be sub-divided into three:-

1. Variety 2
2. Varieties 5,7,3 and 4
3. Varieties 1 and 6

These results are based on both the five and one per cent levels of significance. In the 1968 trial, Variety 4 was found to be distinct from all others at both the five and one per cent significance levels, but this was not borne out by the 1967 results. The placing of Varieties 2 and 7 are based on one year's trial for the same reason as Variety VA.3. However, the results of Variety 2 in particular seem to be conclusive.

Group VC - (Figures 30 and 31)

Results establish the presence of three definite sub-groups:-

1. Varieties 7 and 8
2. Varieties 4 and 3
3. Varieties 1,5,6 and 2

Although in 1967 Varieties 1 and 5 could be separated from Varieties 2 and 6 at both levels of significance, this was not indicated by the 1968 trial results. However, evidence may be sufficient to separate these cultivars after further trials.

Group VD - (Figures 30 and 31)

Results of the "shape analysis" indicate that only two sub-groups can be separated.

1. Variety 2
2. Varieties 1,3,4,5,6,7 and 8

In 1967 Variety 8 was significantly different from all others at the five per cent level and at the one per cent level was significantly different from Varieties 2,3,4,5,6 and 7 but not from Variety 1.

However, in 1968 Variety 8 was found to be significantly different from Varieties 6 and 2 only, and since Variety 6 cannot be separated from Varieties 1,3,4,5 and 7, it would appear that Variety 8 must be placed in sub-group 2.

Group VE - (Figures 32 and 33)

Results indicate that the group cannot be split up any further by this method. In 1967, results at both the five and one per cent significance levels showed no difference between varieties. In 1968 three sub-groups could be separated at the five per cent significance level:-

1. Variety 4
2. Varieties 5,3,2 and 1
3. Variety 6

However, there was no significant difference between any variety at

the one per cent level.

Group VF - (Figures 32 and 33)

Evidence over the two years suggest that this group can possibly be split into two:-

1. Varieties 3,4 and 1
2. Variety 2

In the 1967 results Varieties 3,4 and 1 were significantly different from Variety 2 at the five per cent level and this was confirmed by the 1968 results at the same level, which also showed a significant difference between Variety 1 and Varieties 3 and 4.

At the one per cent level, both years' results are identical showing significant differences between Varieties 1 and 3 with Variety 2, but not between Varieties 1 and 3 and 4 or Variety 4 and Variety 2.

In conclusion, therefore, the "shape-scale" has obvious value in the identification of turnip cultivars, and although limited to a certain degree by environmental effects, the results show sufficient consistency over the two years to merit its use in the future.

"Height"Group VA - (Figures 34 and 35)

Both years' results suggest the presence of two sub-groups:-

1. Variety 5
2. Varieties 1,2,3,4 and 6

which were different at both levels of significance both years.

Group VB - (Figures 34 and 35)

Results show that 3 sub-groups exist:-

1. Variety 2
2. Varieties 4,3,7 and 5
3. Varieties 6 and 1

Although Variety 2 is "split-off" using one year's trial results only (in 1967 the plot contained too many "bolted" plants), the figures are conclusive. Results in this major group show a high degree of consistency over the two years.

Group VC - (Figures 36 and 37)

Figures indicate a degree of 'over-lapping' between the cultivars, but tend to suggest the presence of three sub-groups:-

1. Varieties 8 and 7
2. Varieties 3 and 4
3. Varieties 1,5,6 and 2

Group VD - (Figures 36 and 37)

The results suggest that only two sub-groups exist within this major group:-

1. Variety 2
2. Varieties 1,3,4,5,6,7 and 8

and although the 'dividing off' of Variety 2 is based on the 1968 results only, the results are fairly conclusive. No other divisions of this group can be made using this character as the sole criterion.

Group VE - (Figures 38 and 39)

Evidence here indicates that two sub-groups exist:-

1. Variety 2
2. Varieties 1,3,4,5 and 6

Although Variety 2 was not significantly different from Varieties 6 and 1 in 1967, it was at both levels of significance in 1968 and in both years was consistent in its placing within the group.

Group VF - (Figures 38 and 39)

Both years' results at both significance levels indicate the presence of two groups:-

1. Variety 2
2. Varieties 1,3 and 4

In using this character, while varieties appear once more to fall into a fairly consistent order, there is as expected, a fair degree of 'over-lapping'. Although the use of this character does not divide the sub-groups any more than does the 'shape' character, it does confirm the previous divisions already made.

Group VA - (Figures 40 and 41)

Results show the presence of two sub-groups:-

1. Varieties 1,2,3,4,6 and 7
2. Variety 5

Although Variety 3 was not significant from Variety 5 at the one per cent level, it was at the five per cent level in 1968.

Group VB - (Figures 40 and 41)

The indication of two sub-groups may be considered conclusive despite the fact that Variety 2 is based only on one year's results.

1. Varieties 1,3,4,5,6 and 7
2. Variety 2

Group VC - (Figures 42 and 43)

Although in 1967 the figures show a fair degree of 'over-lapping' between cultivars there is some evidence for the division of this group into three or more sub-groups:-

1. Varieties 7 and 8
2. Varieties 3 and 4
3. Varieties 2,5 and 6
4. Variety 1

Although Varieties 3 and 4 were not significant from Varieties 2,5 and 6 in 1968, they were significantly different at the five per cent level in 1967 and from Variety 2 at the one per cent level in that year.

Variety 1, although not significantly different from Varieties 2,5 and 6 in 1967, was significantly different from all others at the five per cent and one per cent levels in 1968.

Group VD - (Figures 42 and 43)

No division can be made using this character as the sole criterion,

as no significant differences were found between the cultivars.

Group VE - (Figures 44 and 45)

As in Group VD no significant differences were found between cultivars and no sub-groups can be formed.

Group VF - (Figures 44 and 45)

No significant differences between varieties were observed at either level in either years' trials.

While the use of this character in the identification of cultivars is limited, since it seldom makes any 'clear-cut' divisions within groups, it is of value in confirming the previous 'sub-groupings' made by the other characters, and that it divides off Variety 1 from Varities 5,6 and 2 in Group VC.

"Height:Diameter"

Although the order in which cultivars of each group are placed remained fairly consistent over the two years, it was found in general that varieties did not separate out into distinct groups, using this method.

Group VA - (Figures 46 and 47)

Both years' results confirmed that two sub-groups existed:-

1. Variety 5
2. Varieties 1,2,3,4,6 and 7

The placing of Variety 3 is based on one year's trial, as measurements were not recorded in 1967 due to excessive "bolting".

Group VB - (Figures 46 and 47)

There appears to be no 'clear-cut' division into separate sub-groups at either significance level and the records over the two years do not show any real consistency. The results can be summarised as follows:-

1. Variety 2 - Significantly different from the other varieties.
2. Varieties 3 and 7 - Significantly different from Varieties 6 and 1 but not from Variety 4 or 5.
3. Varieties 4,5,6 and 1 - No significant difference between varieties.

Varieties 2 and 7 were only recorded in 1968 due to plot failure in 1967. However, the results of Variety 2 appear fairly conclusive on one year's trial.

Group VC - (Figures 48 and 49)

Results indicate that the group may be divided into three:-

1. Varieties 7 and 8
2. Varieties 3 and 4
3. Varieties 1,2,5 and 6

In the 1967 trial, Variety 4 was not significantly different from Variety 5 at the five per cent significance level, from Variety 1 at the one per cent level. In the 1968 trial, the above groups were confirmed at both significance levels.

Group VD - (Figures 48 and 49)

Although the varieties appear to fall into a definite order, the results show that only Variety 2 can be regarded as sufficiently distinct from the others. This is based on only one year's results, however, although they seem fairly conclusive on this trial.

Group VE - (Figures 50 and 51)

Results show no real consistency over the two years at either significance level, except that Varieties 4 and 2 can be separated from each other at the one per cent level and Varieties 3 and 2 can be separated from each other at the five per cent level but not at the one per cent level.

Group VF - (Figures 50 and 51)

Both years' results confirm at the five and one per cent levels of significance, the presence of two definite sub-groups:-

1. Varieties 1,3 and 4
2. Variety 2

From this evidence the results found by the use of this character confirm the separation into sub-groups made from using the "shape" character. It goes no way to split the sub-groups any further.

Foliage Character

The use of this measurement was of little value as no significant differences were found between varieties in any of the groups except Group VD. Even here, however, there is no necessity for this measurement as the differences between varieties are so great as to enable the "division" to be done subjectively.

LEAF TYPE	BULB COLOUR	CULTIVARS	GROUP	
ENTIRE	White	Milan Pure White	Group I	
	Pale Green Top/White Base	Strap-Leaved Early White Top	Group II	
	Bright Purple Top/White Base	Milan Purple Top Red American Strap-Leaved	Group III	
	White		Tokyo Market	Group IV Can be "Split-off" from Group V on Bulb Size and Shape
			Early Market Early Snowball Little Marvel Model White Pommeranian White Globe Clibrans White Ball Tennis Ball Harbinger	Group V
			Green Top Stone Green Globe Harrison's Improved Green Barrel Norfolk Green Round Manchester Market	Group VI
			Green Tankard	Group VII Can be "Split-off" from Group VI on Shape
			All The Year Round Wallace Fosterton Hybrid Sittlyton Yellow Cropwell Green Top Aberdeen Green Top Balmoral Invincible	Group VIII
	LOBED LYRATE	Green Top/Cream Base	Bortfelder Yellow Tankard	Group IX Can be "Split-off" from Group VIII on Shape
			Golden Ball Golden Sunrise Golden Stone Golden Rose	Group X Can be "Split-off" from Group XI on Plant Size
McCombies Yellow Glenlogie Challenger Yellow Perfection			Group XI	
Blue Cap Purple Top White Purple Top Mammoth Lincoln Red Globe Greystone Red Globe			Group XII	
Purple Top Yellow Purple Top Scotch Bruce Renown			Group XIII	
Bright Purple Top/White Base				
Dark Purple Top/White Base				

FURTHER CLASSIFICATION USING "NEW TECHNIQUES"

<u>GROUP</u>	<u>CULTIVAR</u>
Group I	Milan Pure White
Group II	Strap-leaved Early White Top
Group III	Milan Purple Top Red American Strap-leaved
Group IV	Tokyo Market
Group V	Early Snowball Early Market Little Marvel Model White Clibrans White Ball Tennis Ball Harbinger
Group VA	Pommeranian White Globe
Group VB	Harrison's Improved Green Barrel Norfolk Green Round
Group VIA	Green Top Stone Manchester Market
Group VII	Green Tankard
Group VIII	Sittyton Yellow Fosterton Hybrid Sheepfold Yellow Balmoral Invincible
Group VIIIA	Cropwell Green Top Aberdeen Green Top Wallace
Group VIIIB	All The Year Round
Group IX	Bortfelder Yellow Tankard
Group X	Golden Ball Golden Stone Golden Rose
Group XA	Golden Sunrise
Group XI	McCombies Yellow Glenlogie Challenger Yellow Perfection

GROUPCULTIVAR

Group XII

Blue Cap
Lincoln Red Globe
Purple Top Mammoth
Greystone
Red Globe

Group XIII

Purple Top White

Group XIII

Purple Top Yellow
Bruce
Renown

Group XIII

Purple Top Scotch

DISCUSSION

The initial breakdown of cultivars using the taxonomic characters of leaf-type, bulb colour, bulb shape (in the case of Tokyo Market and the "tankard" cultivars) and foliage height, divide the list into 13 groups. While these characters are wholly subjective, they can be referred to as 'non-continuous' in nature as the divisions they make are discrete and no overlapping between groups exist. Their value, as can be seen from the classification on page 75, although useful, remain limited in so much as the cultivars are only divided into 13 sections and no further identification or division can be made by these means.

The classification and identification of cultivars can be taken much further through the use of the new criterion such as 'bulb shape', and objective measurements of the bulb. The observations on each cultivar are done in random plots due to the heterogeneous nature of the species. From the 13 previous groups, there now emerge 20.

As can be seen from the classification on pages 76 and 77, the "shape" character is responsible for the division of the following cultivars into their new sub-groups:-

In Group V - Pommeranian White Globe is separated from the other cultivars in both years.

In Group VI - Manchester Market and Green Top Stone are separated out.

In Group VIII - All The Year Round, Cropwell Green Top and Wallace can be distinguished from the rest.

In Group X - Golden Sunrise can be separated off from Golden Ball, Golden Stone and Golden Rose.

In Group XIII - 'Bulb shape' alone distinguishes Purple Top Scotch from the others in its previous group.

From the frequency distribution histograms (pages 28 to 39) the variation of this character over the two years can be observed.

In Groups VA, VB, VE and VF no cultivar showed much variation between years. Only 'Wallace' which is Variety 2 in Group VC and 'Challenger', Variety 7 in Group VD, deviate in this way. Both are of great age and have been subject to faulty selection procedures in the past. This probably accounts for the existence of such a large proportion of atypical forms.

Thus the "Shape" technique as detailed on page 65 appears to be a most useful taxonomic character in varietal identification. A proportion of the previous groups can be sub-divided further using this method and new sub-groups identified. Although partly subjective in nature, the classes of:-

1. Flat
2. Round
3. Globe
4. Semi-tankard
5. Oval-tankard
6. Tankard

are sufficiently distinct as seen by the photographs on pages

In using this method of identification, as with the other 'random-plot' characters, care must be taken with the agronomic side of the experiment to ensure uniformity of each cultivar both within and between years.

The use of the objective measurements of bulb height, bulb diameter and height/diameter ratio of the bulb, as taxonomic

characters for identification, are of value, in so much as they confirm the divisions made by the 'shape' technique. The sub-divisions of major groups using these techniques are not so distinct as with the "shape" method, and as expected a degree of overlapping between the sub-groups was observed.

The character of bulb height has an additional value in identification for it can separate Purple Top White in Group XI from the other cultivars, which cannot be done using any other technique .

Similarly in Group VIII, "bulb diameter" can separate the cultivar All The Year Round from the others which cannot be done by any other method.

Whether starting with "shape" or colour of the bulb, or any of the objective techniques used, the resulting classification would be the same. Colour was used as the initial character for grouping the cultivars as it is an accepted taxonomic character used in previous classifications and, although subjective in nature the divisions made are discrete.

In conclusion, therefore, by using the criteria of bulb shape and measurement, a new classification of turnip cultivars has been devised and several cultivars, which hitherto have been classed as synonyms, can now be identified as distinct.

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APPENDIX

Shape Analysis 1967Group VA

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	1.95	1.85	2.10	1.85	2.20	1.80	11.75	23.14	170.10	1.96
2	2.40	1.75	2.05	2.20	2.30	1.95	12.65	29.96		2.11
3	-	-	-	-	-	-				
4	2.00	1.90	1.50	1.70	2.20	1.85	11.15	21.01		1.86
5	3.30	3.05	2.55	3.10	3.20	3.00	18.20	55.54		3.03
6	1.60	2.35	1.90	2.00	2.00	1.95	11.80	23.50		1.97
7	1.90	1.95	1.65	1.80	2.10	1.90	11.30	21.40		1.88
<u>Totals (T)</u>	<u>13.15</u>	<u>12.85</u>	<u>11.75</u>	<u>12.65</u>	<u>14.00</u>	<u>12.45</u>	<u>76.85</u>	<u>171.55</u>		
<u>S.S.</u>	<u>30.62</u>	<u>28.72</u>	<u>23.70</u>	<u>28.00</u>	<u>33.62</u>	<u>26.88</u>				

T²/n

164.52

$$\text{Correction Factor} = \frac{76.85^2}{36} = 164.05$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

$$\text{Totals S.S.} = 171.55 - 164.05 = 7.50 \quad 35$$

$$\text{Between Vars.} = 170.10 - 164.05 = 6.05 \quad 5 \quad 1.21 \quad 30.25 \quad 2.60 \quad 3.86$$

$$\text{Between Reps.} = 164.52 - 164.05 = 0.47 \quad 5 \quad 0.09 \quad 2.25$$

$$\text{Error S.S.} = 0.98 \quad 25 \quad 0.04$$

$$\text{M.S.D.} = \sqrt{\frac{0.04 \times 2}{6}} = 0.11 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.06	2.79
0.23	0.31

<u>Variety</u>		<u>5%</u>	<u>1%</u>
5	3.03	-	-
2	2.11	}	}
6	1.97		
1	1.96		
7	1.88		
4	1.86		

Shape Analysis 1968Group VA

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	2.65	2.25	2.50	2.10	2.55	2.35	14.40	34.77		2.40
2	2.00	2.25	2.30	2.10	2.65	2.35	13.65	31.31		2.28
3	2.20	2.90	2.05	2.50	2.55	2.40	14.60	35.97		2.43
4	2.30	2.35	2.15	2.30	2.25	2.30	13.65	31.08		2.28
5	2.90	2.85	3.40	2.85	3.50	3.00	18.50	57.47		3.08
6	2.20	2.20	2.25	2.60	2.40	2.50	14.15	33.51		2.36
7	2.50	2.05	2.40	2.35	2.50	1.85	13.65	31.41	253.66	2.28
Totals(T)	16.75	16.85	17.05	16.80	18.40	16.75	102.60			
S.S.	40.65	41.22	42.75	40.77	49.35	40.77		255.52		
T ² /n									250.94	

$$\text{Correction Factor} = \frac{102.60^2}{42} = 250.64$$

	Degrees of Freedom	Variance	F. by Calculation		F. from Tables	
			5%	1%	5%	1%
<u>Totals S.S.</u>	41	255.52 - 250.64 = 4.88				
<u>Between Vars.</u>	6	253.66 - 250.64 = 3.02	0.50	10.00	2.42	3.47
<u>Between Reps.</u>	5	250.94 - 250.64 = 0.30	0.06	1.20		
<u>Error S.S.</u>	30	1.56	0.05			
<u>M.S.D.</u>		$\sqrt{\frac{0.05 \times 2}{6}} = 0.13$	t at 5%	t at 1%		
			2.04	2.75		
			0.27	0.36		

<u>Variety</u>		<u>5%</u>	<u>1%</u>
5	3.08		
3	2.43	}	}
1	2.40		
6	2.36		
2	2.28		
4	2.28		
7	2.28		

Shape Analysis 1967Group VB

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	2.50	2.40	2.55	2.25	2.25	2.45	14.40	34.64		2.40
3	2.70	2.95	2.95	2.95	3.05	3.00	17.60	51.70		2.93
4	3.20	3.45	3.40	3.15	3.00	3.10	19.30	62.24		3.22
5	3.05	2.90	3.00	3.55	3.15	3.05	18.70	58.54		3.12
6	2.75	2.15	2.35	2.15	2.75	2.25	14.40	34.96	241.11	2.40
Totals (T)	14.20	13.85	14.25	14.05	14.20	13.85	84.40			
<u>S.S.</u>	40.65	39.40	41.29	40.91	40.85	38.98		242.08		
T ² /n									237.48	

$$\text{Correction Factor} = \frac{84.40^2}{30} = 237.45$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u>	= 242.08 - 237.45 = 4.63	29			
<u>Between Vars.</u>	= 241.11 - 237.45 = 4.34	4	1.085	8.35	2.87
<u>Between Reps.</u>	= 237.48 - 237.45 = 0.03	5	0.005	0.46	
<u>Error S.S.</u>	= 0.26	20	0.013		
<u>M.S.D.</u>	= $\sqrt{\frac{.013 \times 2}{6}}$				
				0.066 x t at 5%	t at 1%
				2.086	2.845
				0.14	0.19

<u>Varieties</u>		5%	1%
4	3.22	}	}
5	3.12		
3	2.93	}	}
1	2.40		
6	2.40		

Shape Analysis 1968Group VB

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	2.30	2.20	2.00	2.45	2.10	2.35	13.40	30.07	2.23	
2	6.00	6.00	6.00	6.00	6.00	6.00	36.00	26.00	6.00	
3	3.05	2.60	2.75	2.95	2.65	2.60	16.60	46.11	2.77	
4	3.00	3.15	3.30	3.25	3.40	3.25	19.35	62.50	3.23	
5	2.75	2.95	2.90	2.90	2.90	3.20	17.60	51.74	2.93	
6	2.45	2.15	2.10	2.00	2.25	2.35	13.30	29.62	2.22	
7	2.70	2.75	2.55	3.05	3.30	3.05	17.40	50.85	2.90	
Totals(T)	22.25	21.80	21.60	22.80	22.60	22.60	133.65			
S.S.	80.45	78.41	77.78	83.91	83.36	82.98		486.89		
T ² /n								425.46		

$$\text{Correction Factor} = \frac{133.65^2}{42} = 425.29$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u>	= 486.89 - 425.29 = 61.60	41			
<u>Between Vars.</u>	= 485.83 - 425.29 = 60.54	6	10.01	333.67	2.42
<u>Between Reps.</u>	= 425.46 - 425.29 = 0.17	5	0.03	1.00	3.47
<u>Error S.S.</u>	= 0.99	30	0.03		
<u>M.S.D.</u>	= $\sqrt{\frac{0.03 \times 2}{6}}$		0.1	t at 5%	t at 1%
				2.04	2.75
				0.20	0.28

<u>Variety</u>		<u>5%</u>	<u>1%</u>
2	6.00	-	-
4	3.23	-	-
5	2.93	}	}
7	2.90		
3	2.77		
1	2.23	}	}
6	2.22		

Shape Analysis 1968Group VC

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	3.05	3.10	2.90	2.75	2.65	3.25	17.70	52.47		2.95
2	2.80	2.95	2.90	2.65	2.85	2.80	16.95	47.94		2.83
3	3.55	3.50	3.35	3.40	3.40	3.15	20.35	69.12		3.39
4	3.30	3.60	3.60	3.35	3.65	3.45	20.95	73.26		3.49
5	2.85	2.75	2.00	2.70	2.75	3.15	16.70	46.71		2.78
6	2.85	2.70	2.45	2.65	2.65	2.55	15.85	41.96		2.64
7	6.00	6.00	6.00	6.00	6.00	6.00	36.00	216.00		6.00
8	6.00	6.00	6.00	6.00	6.00	6.00	36.00	216.00	762.62	6.00
Totals(T)	30.40	30.60	29.70	29.50	29.95	30.35	180.50			
S.S.	128.88	130.38	125.26	123.68	126.61	128.65		763.46		
T ² /n									678.87	

$$\text{Correction Factor} = \frac{180.50^2}{48} = 678.76$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u>	= 763.46 - 678.76 = 84.70	47			
<u>Between Vars.</u>	= 762.62 - 678.76 = 83.86	7	11.98	599.00	2.30 3.21
<u>Between Reprs.</u>	= 678.87 - 678.76 = 0.11	5	0.02	1.00	
<u>Error S.S.</u>	= 0.73	35	0.02		
<u>M.S.D.</u>	= $\sqrt{\frac{0.02 \times 2}{6}}$ = 0.08 x t at 5% and t at 1%				
				2.03	2.73
				0.16	0.22

<u>Variety</u>		5%	1%
8	6.00	}	}
7	6.00		
4	3.49	}	}
3	3.39		
1	2.95	}	}
2	2.83		
5	2.78	}	}
6	2.64		

Shape Analysis 1967Group VD

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	2.65	2.70	3.05	2.90	3.15	2.75	17.20	49.51	2.87	
2	1.00	1.00	1.00	1.00	1.00	1.00	6.00	6.00	1.00	
3	3.15	2.90	2.80	2.35	2.85	2.25	16.30	44.88	2.72	
4	3.00	2.85	3.05	2.40	3.00	2.30	16.60	46.48	2.77	
5	3.10	2.80	2.95	2.95	2.35	2.70	16.85	47.67	2.81	
6	2.80	2.45	2.85	2.80	2.60	2.80	16.30	44.41	2.72	
7	2.90	2.60	2.75	3.10	2.70	2.95	17.00	48.34	347.30	
8	3.34	3.05	3.35	3.60	3.35	2.60	19.29	62.62	3.22	
Totals (T)	21.94	20.35	21.80	21.10	21.00	19.35	125.54			
S.S.	63.96	54.73	63.06	59.81	58.84	49.51		349.91		
T ² /n								328.92		

$$\text{Correction Factor} = \frac{125.54^2}{48} = 328.34$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Totals S.S.</u> = 349.91 - 328.34 = 21.57	47				
<u>Between Vars.</u> = 347.30 - 328.34 = 18.96	7	2.71	46.72	2.28	3.18
<u>Between Reps.</u> = 328.92 - 328.34 = 0.58	5	0.12	2.07		
<u>Error S.S.</u> = 2.03	35	0.58			
<u>M.S.D.</u> = $\sqrt{\frac{0.058 \times 2}{6}}$ = 0.14 x t at 5% and t at 1%					
		2.030	2.724		
		0.28	0.38		

<u>Varieties</u>		5%	1%
8	3.22	-	-
1	2.87	}	}
7	2.83		
5	2.81		
4	2.77		
6	2.72		
3	2.72	-	-
2	1.00	-	-

Shape Analysis 1967Group VE

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	3.35	3.30	3.10	3.30	3.20	2.95	19.20	61.56	403.44	3.20
2	3.50	3.30	3.15	3.10	3.70	3.30	20.05	67.25		3.34
3	3.40	3.35	3.45	3.85	3.50	3.35	20.90	72.98		3.48
4	3.40	3.75	3.65	3.55	3.45	3.70	21.50	77.14		3.58
5	3.30	3.25	3.40	3.15	3.25	3.30	19.65	64.39		3.28
6	3.20	2.90	3.50	2.55	3.15	3.80	19.10	61.77		3.18
Totals (T)	20.15	19.85	20.25	19.50	20.25	20.40	120.40			
S.S.	67.72	66.04	68.57	64.35	68.57	69.84		405.09		
T ² /n								402.76		

$$\text{Correction Factor} = \frac{120.40^2}{36} = 402.67$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u>	= 405.09 - 402.67 = 2.42	35			
<u>Between Vars.</u>	= 403.44 - 402.67 = 0.77	5	0.15	2.50	2.60
<u>Between Reps.</u>	= 402.76 - 402.67 = 0.09	5	0.02	0.33	
<u>Error S.S.</u>	= 1.56	25	0.06		

<u>Variety</u>		5%	1%
4	3.58	}	}
3	3.48		
2	3.34		
5	3.28		
1	3.20		
6	3.18		

Shape Analysis 1968
Group VE

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI	Totals			
1	3.05	2.95	3.05	3.00	2.70	2.50	17.25	49.85		2.88
2	2.90	3.05	2.90	3.20	3.20	3.30	18.55	57.49		3.09
3	3.15	3.20	3.20	3.30	2.90	2.95	18.70	58.41		3.12
4	3.30	3.90	3.60	3.60	3.50	3.65	21.55	77.59		3.59
5	3.25	3.20	3.35	3.25	3.00	2.70	18.75	58.88		3.13
6	2.25	2.55	2.85	3.15	2.55	3.00	16.35	45.11	345.77	2.73
Totals(T)	17.90	18.85	18.95	19.50	17.85	18.10	111.15			
S.S.	54.15	60.20	60.26	63.58	53.69	55.46		347.34		
T ² /n									343.55	

Correction Factor = $\frac{111.15^2}{36} = 343.18$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

Total S.S. = 347.34 - 343.18 = 4.16 35

Between Vars. = 345.77 - 343.18 = 1.59 5 0.32 3.56 2.60 3.86

Between Reps. = 343.55 - 343.18 = 0.37 5 0.07 0.78

Error S.S. = 2.20 25 0.09

M.S.D. = $\sqrt{\frac{0.09 \times 2}{6}} = 0.17 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$

2.06	2.79
0.35	0.47

<u>Variety</u>		5%	1%
4	3.59	}	}
5	3.13		
3	3.12		
2	3.09		
1	2.88		
6	2.73		

Shape Analysis 1967
Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	3.15	3.10	3.30	2.90	3.10	3.05	18.60	57.75	206.37	3.10
2	2.30	2.90	2.95	2.45	2.45	2.30	15.35	39.70		2.56
3	3.05	3.35	3.30	3.30	3.20	2.75	18.95	60.11		3.16
4	2.70	2.80	2.70	3.20	2.80	3.05	17.25	49.80		2.88
Totals(T)	11.20	12.15	12.25	11.85	11.55	11.15	70.15			
S.S.	31.81	37.08	37.77	35.54	33.69	31.46		207.36		
T ² /n								205.32		

Correction Factor = $\frac{70.15^2}{24} = 205.04$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Totals S.S.</u> = 207.36 - 205.04 = 2.32	23				
<u>Between Vars.</u> = 206.37 - 205.04 = 1.33	3	0.44	9.36	3.29	5.42
<u>Between Reps.</u> = 205.32 - 205.04 = 0.28	5	0.56	11.91		
<u>Error S.S.</u> = 0.71					
<u>M.S.D.</u> = $\sqrt{\frac{0.047 \times 2}{6}}$ = 0.13 x t at 5% and t at 1%				2.131	2.947
				0.28	0.38

<u>Variety</u>		5%	1%
3	3.16	}	}
1	3.10		
4	2.88	}	}
2	2.56		

Height Analysis 1967Group VA

Var.	<u>Replication</u>						(T)		T ² /n	Average
	I	II	III	IV	V	VI	Totals	S.S.		
1	12.0	13.0	12.3	11.6	12.7	11.4	73.0	890.10		12.2
2	13.8	12.1	12.6	11.3	11.4	11.6	72.8	887.82		12.1
4	11.7	12.0	13.7	12.1	12.7	12.1	74.3	922.69		12.4
5	16.7	14.7	12.2	15.6	13.5	15.6	88.3	1,312.79		14.7
6	11.6	12.6	12.1	12.2	11.5	12.1	72.1	867.23		12.0
7	12.8	13.3	12.1	11.2	11.9	12.7	74.0	915.48		12.3
Totals(T)	78.6	77.7	75.0	74.0	73.7	75.5	454.5		5,770.11	
S.S.	1,048.62	1,011.15	939.140	926.30	908.65	961.99			5,796.11	
T ² /n									5,741.37	

$$\text{Correction Factor} = \frac{454.5^2}{36} = 5,738.06$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

$$\text{Total S.S.} = 5,796.11 - 5,738.06 = 58.05$$

35

$$\text{Between Vars.} = 5,770.11 - 5,738.06 = 32.05$$

5

6.41

7.04

2.42

3.47

$$\text{Between Reps.} = 5,741.37 - 5,738.06 = 3.31$$

5

0.66

0.73

$$\text{Error S.S.} = 22.69$$

25

0.91

$$\text{M.S.D.} = \sqrt{\frac{0.91 \times 2}{6}} = 0.55 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.06	2.79
1.13	1.53

<u>Variety</u>		<u>5%</u>	<u>1%</u>
5	14.7	}	}
4	12.4		
7	12.3		
1	12.2		
2	12.1		
6	12.0		

Height Analysis 1968

Var.	Replication						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	14.35	11.25	12.85	12.35	12.15	12.75	75.70	960.32	931.23	12.62
2	11.75	12.70	12.15	12.20	12.90	13.00	74.70	93.23		12.45
3	12.55	13.05	13.20	12.00	11.70	12.05	74.55	928.14		12.43
4	12.50	12.25	11.65	12.45	13.15	12.95	74.95	937.66		12.49
5	14.65	13.80	13.75	14.75	17.00	14.35	88.30	1,306.61		14.72
6	12.15	11.20	11.05	12.95	12.60	13.55	73.50	905.23		12.25
7	12.70	12.65	11.85	13.30	13.65	12.15	76.30	972.57		12.72
Totals(T)	90.65	86.90	86.50	90.00	93.15	90.80	538.00		6,917.77	
S.S.	1,181.27	1,084.12	1,074.30	1,162.52	1,257.93	1,181.62		6,941.76		
T ² /n									6,896.12	

$$\text{Correction Factor} = \frac{538.00^2}{42} = 6,891.52$$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Total S.S.</u> = 6,941.76 - 6,891.52 = 50.24	41				
<u>Between Vars.</u> = 6,917.77 - 6,891.52 = 26.25	6	4.38	6.74	2.42	3.47
<u>Between Reps.</u> = 6,896.12 - 6,891.52 = 4.60	5	0.92	1.42		
<u>Error S.S.</u> = 19.39	30	0.65			
<u>M.S.D.</u> = $\sqrt{\frac{0.65 \times 2}{6}}$ = 0.47 x t at 5% and t at 1%					
		2.042	2.750		
		0.96	1.29		

Variety		5%	1%
5	14.72	}	}
7	12.72		
1	12.62		
4	12.49		
2	12.45		
3	12.43		
6	12.25		

Height Analysis 1967Group VB

Var.	<u>Replication</u>						(T)		T ² /n	Average
	I	II	III	IV	V	VI	Totals	S.S.		
1	11.8	13.4	12.5	10.6	11.8	12.4	72.5	880.41		12.1
3	14.5	15.8	14.9	13.9	13.0	12.5	84.6	1,200.36		14.1
4	16.1	15.2	13.9	13.0	14.6	13.8	86.6	1,256.06		14.4
5	15.3	15.6	15.3	15.0	14.2	16.6	92.0	1,413.74		15.3
6	12.7	12.1	11.7	11.6	11.9	12.2	72.2	869.60		12.0
Totals(T)	70.4	72.1	68.3	64.1	65.5	67.5	407.9	5,620.17	5,598.30	
S.S.	1,004.08	1,050.01	942.45	834.13	864.65	924.85				

$$T^2/n = 5,554.95$$

$$\text{Correction Factor} = \frac{407.9^2}{30} = 5,546.08$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

$$\text{Total S.S.} = 5,620.17 - 5,546.08 = 74.09$$

29

$$\text{Between Vars.} = 5,598.30 - 5,546.08 = 52.22$$

4

13.06

20.09

2.42

3.47

$$\text{Between Reps.} = 5,554.95 - 5,546.08 = 8.87$$

5

1.77

2.72

$$\text{Error S.S.} = 13.00$$

20

0.65

$$M.S.D. = \sqrt{\frac{0.65 \times 2}{6}} = 0.48 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.086	2.845
1.00	1.37

<u>Variety</u>		5%	1%
5	15.3	}	}
4	14.4		
3	14.1		
1	12.1	}	}
6	12.0		

Height Analysis 1968

Group VB

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	12.75	12.15	10.90	13.55	11.90	13.75	75.00	943.27	12.50	
2	19.15	21.15	22.30	20.95	22.20	22.40	128.15	2,744.84	21.36	
3	16.65	17.10	15.40	15.95	15.65	14.35	95.10	1,512.04	15.85	
4	15.15	16.80	16.30	15.80	15.55	16.50	96.10	1,541.15	16.02	
5	17.10	14.60	12.45	15.45	16.60	15.40	91.60	1,412.00	15.27	
6	11.60	12.85	10.60	16.40	11.50	13.15	76.10	986.18	12.68	
7	15.55	15.55	15.55	15.55	16.80	15.50	94.50	1,489.70	15.75	

Totals(T) 107.95 110.20 103.50 113.65 110.20 111.05 656.55 10,573.11

S.S. 1,704.80 1,789.68 1,628.12 1,876.01 1,811.23 1,819.33 10,629.18

T²/n 10,271.71

Correction Factor = $\frac{656.55^2}{42}$ = 10,263.28

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 10,629.18 - 10,263.28
= 365.90

41

Between Vars. = 10,573.11 - 10,263.28
= 309.83

6

51.64

32.48

2.42

3.47

Between Reps. = 10,271.71 - 10,263.28
= 8.43

5

1.69

1.06

Error S.S. = 47.64

30

1.59

M.S.D. = $\sqrt{\frac{1.59 \times 2}{6}}$ = 0.73 x t at 5% and t at 1%

	2.042	2.750
	1.49	2.00

<u>Variety</u>		<u>5%</u>	<u>1%</u>
2	21.36	—	—
4	16.02	}	}
3	15.85		
7	15.75		
5	15.27	}	}
6	12.68		
1	12.50		

Height Analysis 1967

Group VC

Var.	Replication						(T)		T ² /n	Average
	I	II	III	IV	V	VI	Totals	S.S.		
1	17.8	15.3	14.5	16.7	15.4	15.5	95.2	1,517.48		15.9
2	13.6	11.6	13.2	13.2	12.0	13.8	77.4	1,002.44		12.9
3	18.8	18.3	17.5	15.8	18.1	18.4	106.9	1,910.39		17.8
4	19.3	16.9	16.7	18.3	15.8	18.1	105.1	1,849.13		17.5
5	16.1	16.2	18.0	15.1	15.0	14.9	95.3	1,520.67		15.9
6	13.3	13.8	15.3	14.7	12.8	14.6	84.5	1,194.51		14.1
7	26.9	26.0	28.1	26.1	27.5	28.1	162.7	4,416.29		27.1
8	32.4	28.7	33.9	31.6	27.4	29.9	183.9	5,665.99		30.7
Totals(T)	158.2	146.8	157.2	151.5	144.0	153.3	911.0		19,006.71	

S.S. 3,437.20 2,941.72 3,466.54 3,161.53 2,854.26 3,215.65 19,076.90

T²/n 17,309.80

Correction Factor = $\frac{911.02}{48} = 17,290.02$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%

Total S.S. = 19,076.90 - 17,290.02
= 1,786.88

47

Between Vars. = 19,006.71 - 17,290.02
= 1,716.69

7

245.24 170.31

2.30 3.21

Between Reps. = 17,309.80 - 17,290.02
= 19.78

5

3.96 2.75

Error S.S. = 50.41

35

1.44

M.S.D. = $\sqrt{\frac{1.44 \times 2}{6}} = 0.69 \times t$ at 5% and t at 1%

	2.03	2.72
	1.40	1.88

Variety	5%	1%
8	30.7	-
7	27.1	-
3	17.8	}
4	17.5	
5	15.9	
1	15.9	
6	14.1	
2	12.9	

Height Analysis 1968Group VCReplication

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	16.40	15.90	15.35	14.00	14.00	14.35	90.00	1,355.32		15.00
2	12.80	11.85	13.00	12.85	12.65	12.30	75.45	949.70		12.58
3	16.15	17.60	19.85	15.50	13.80	14.50	97.40	1,605.55		16.23
4	18.00	18.55	18.40	12.10	16.90	17.10	101.05	1,731.09		16.84
5	12.50	14.65	14.05	13.95	11.95	14.20	81.30	1,107.32		13.55
6	13.90	13.35	13.20	14.10	13.80	11.90	80.25	1,076.53		13.38
7	25.20	24.95	24.80	22.20	22.80	23.80	143.75	3,451.70		23.96
8	25.30	25.70	26.00	23.35	22.75	24.50	147.60	3,639.62		24.60
Totals(T)	140.25	142.55	144.65	128.05	128.65	132.65	816.80		14,831.69	

S.S. 2,642.21 2,722.93 2,799.89 2,179.26 2,202.72 2,369.81 14,916.83

T²/n 13,932.23

Correction Factor = $\frac{816.80^2}{48} = 13,899.21$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 14,916.83 - 13,899.21
= 1,017.62

47

Between Vars. = 14,831.69 - 13,899.21
= 932.48

7

133.21

89.40

2.30

3.21

Between Reps. = 13,932.23 - 13,899.21
= 33.02

5

6.60

4.43

Error S.S. = 52.12

35

1.49

M.S.D. = $\sqrt{\frac{1.49 \times 2}{6}} = 0.71 \times t$ at 5% and t at 1%

2.03

2.72

1.44

1.93

<u>Variety</u>	5%	1%
8	24.60	}
7	23.96	
4	16.84	
3	16.23	
1	15.00	
5	13.55	
6	13.38	
2	12.58	

Height Analysis 1967

Group VD

Replication

Var.	I	II	III	IV	V	VI	(T) Totals	S.S.	T ² /n	Average
1	13.4	12.8	13.1	13.2	11.7	14.1	78.3	1,024.95		13.1
2	10.7	8.6	9.0	8.1	8.8	7.6	52.8	470.26		8.8
3	13.4	12.2	13.2	10.8	12.1	11.4	73.1	895.65		12.2
4	14.4	12.5	13.4	11.7	11.9	12.7	76.6	982.96		12.8
5	15.2	14.5	14.8	12.8	14.2	13.4	84.9	1,205.37		14.2
6	16.5	14.7	14.4	13.0	13.7	13.2	85.5	1,226.63		14.3
7	13.5	13.9	14.0	15.9	13.3	14.0	84.6	1,197.16		14.1
8	14.2	15.6	14.8	15.2	16.1	13.1	89.0	1,325.90		14.8
Totals(T)	111.3	104.8	106.7	100.7	101.8	99.5	624.8		8,287.72	

S.S. 1,568.15 1,405.80 1,447.85 1,310.07 1,327.78 1,269.23 8,328.88

T²/n 8,144.95

Correction Factor = $\frac{624.8^2}{48} = 8,132.81$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Totals S.S. = 8,328.88 - 8,132.81
= 196.07

47

Between Vars. = 8,287.72 - 8,132.81
= 154.91

7

22.13

26.66

2.28

3.18

Between Reps. = 8,144.95 - 8,132.81
= 12.14

5

2.43

2.93

Error S.S. = 29.02

35

0.83

M.S.D. = $\sqrt{\frac{0.83 \times 2}{6}} = 0.53 \times t$ at 5% and t at 1%

2.03	2.72
1.08	1.44

<u>Variety</u>		5%	1%
8	14.8	}	}
6	14.3		
5	14.2		
7	14.1		
1	13.1		
4	12.8		
3	12.2		
2	8.8		

Height Analysis 1968

Group VD

Replication

Var.	Replication						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	11.95	12.80	11.90	11.10	11.50	12.30	71.55	855.00		11.93
3	12.75	12.20	13.15	12.00	11.55	12.05	73.70	906.93		12.28
4	12.35	12.10	13.85	12.65	12.15	12.95	76.05	966.10		12.68
5	13.00	13.35	14.00	12.20	13.35	12.35	78.25	1,022.81		13.04
6	13.45	13.80	13.60	12.05	13.60	13.20	79.70	1,060.71		13.28
7	11.10	12.70	13.20	12.35	11.35	12.50	73.20	896.34		12.20
8	13.85	11.70	16.30	12.05	14.35	13.30	8.55	1,122.42		13.59

Totals(T) 88.45 88.65 96.00 84.40 87.85 88.65 534.00 6,803.08

S.S. 1,122.82 1,125.93 1,327.25 1,019.00 1,111.20 1,124.10 6,830.31

T²/n 6,799.72

Correction Factor = $\frac{534.00^2}{42} = 6,789.43$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

Total S.S. = 6,830.31 - 6,789.43
= 40.88

41

Between Vars. = 6,803.08 - 6,789.43
= 13.65

6

2.28

4.07

2.42

3.47

Between Reps. = 6,799.72 - 6,789.43
= 10.29

5

2.06

3.68

Error S.S. = 16.94

30

0.56

M.S.D. = $\sqrt{\frac{0.56 \times 2}{6}} = 0.44$ x t at 5% and t at 1%

	2.042	2.750
	0.90	1.21

<u>Variety</u>		5%	1%
8	13.59	}	}
6	13.28		
5	13.04		
4	12.68		
3	12.28		
7	12.20		
1	11.93		

Height Analysis 1967Group VE

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	13.2	11.9	15.4	15.8	14.3	13.6	84.2	1,192.10		14.0
2	13.5	12.6	13.0	13.8	14.4	13.5	80.8	1,090.06		13.5
3	14.1	14.3	16.4	18.0	14.6	15.7	93.1	1,455.91		15.5
4	13.5	14.6	14.3	14.9	14.2	18.3	89.8	1,358.44		15.0
5	15.3	15.3	14.8	15.3	14.3	18.1	93.1	1,453.41		15.5
6	12.0	13.7	15.1	17.5	14.9	15.5	88.7	1,328.21		14.8
Totals(T)	81.6	82.4	89.0	95.3	86.7	94.7	529.7		7,814.21	
S.S.	1,115.64	1,139.80	1,326.66	1,526.43	1,253.15	1,516.45		7,878.14		
T ² /n									7,822.73	

$$\text{Correction Factor} = \frac{529.7^2}{36} = 7,793.95$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

$$\text{Total S.S.} = 7,878.14 - 7,793.95 = 84.19$$

35

$$\text{Between Vars.} = 7,814.21 - 7,793.95 = 20.26$$

5

4.05

2.87

2.60

3.86

$$\text{Between Reps.} = 7,822.73 - 7,793.95 = 28.78$$

5

5.76

4.09

$$\text{Error S.S.} = 35.15$$

25

1.41

$$\text{M.S.D.} = \sqrt{\frac{1.41 \times 2}{6}} = 0.69 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.06

2.79

1.42

1.93

<u>Variety</u>	5%	1%
3	15.5	}
5	15.5	
4	15.0	
6	14.8	
1	14.0	
2	13.5	

Height Analysis 1968

Group VE

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	14.50	13.10	11.20	13.80	15.30	15.00	82.90	1,156.83		13.82
2	11.65	8.20	9.35	7.95	7.85	8.35	53.35	484.93		8.89
3	13.75	15.00	14.05	15.00	14.35	15.95	88.10	1,296.79		14.68
4	13.95	13.20	13.20	15.50	13.00	13.00	81.85	1,121.33		13.64
5	16.15	13.90	13.55	15.25	12.00	13.25	84.10	1,189.76		14.02
6	14.80	14.90	12.55	14.60	12.45	13.65	82.95	1,153.04		13.83
Totals(T)	84.80	78.30	73.90	82.10	74.95	79.20	473.25		6,355.53	
S.S.	1,209.50	1,053.31	925.61	1,164.62	969.64	1,080.01			6,402.69	
T ² /n										6,235.62

Correction Factor = $\frac{473.25^2}{36} = 6,221.27$

	Degrees of Freedom	Variance	<u>F. by Calculation</u>		<u>F. from Tables</u>	
			5%	1%	5%	1%
<u>Total S.S.</u> = 6,402.69 - 6,221.27 = 181.42	35					
<u>Between Vars.</u> = 6,355.53 - 6,221.27 = 134.26	5	26.85	20.50	2.60	3.86	
<u>Between Reps.</u> = 6,235.62 - 6,221.27 = 14.35	5	2.87	2.19			
<u>Error S.S.</u> = 32.81	25	1.31				
<u>M.S.D.</u> = $\sqrt{\frac{1.31 \times 2}{6}}$ = 0.66 x t at 5% and t at 1%						
			2.06	2.79		
			1.36	1.84		

<u>Variety</u>	5%	1%
3	14.68	}
5	14.02	
6	13.83	
1	13.82	
4	13.64	
2	8.89	

Height Analysis 1967

Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI	Totals			
1	15.2	14.2	17.2	15.8	16.1	17.7	96.2	1,550.66		16.0
2	12.1	13.4	13.4	12.9	12.3	13.0	77.1	992.23		12.9
3	15.7	14.5	14.6	17.3	14.6	16.2	92.9	1,444.79		15.5
4	15.2	14.1	13.2	16.0	15.2	15.9	89.6	1,343.94		14.9
Totals(T)	58.2	56.2	58.4	62.0	58.2	62.8	355.8		5,309.57	
S.S.	854.98	790.26	862.80	971.34	854.70	997.54		5,331.62		
T ² /n								5,282.83		

Correction Factor = $\frac{355.8^2}{24} = 5,274.74$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 5,331.62 - 5,274.74
= 56.88

23

Between Vars. = 5,309.57 - 5,274.74
= 34.83

3

11.61

12.48

3.29

5.42

Between Reps. = 5,282.83 - 5,274.74
= 8.09

5

1.62

1.74

Error S.S. = 13.96

15

0.93

M.S.D. = $\sqrt{\frac{0.93 \times 2}{6}} = 0.56 \times t$ at 5% and t at 1%

2.131	2.947
1.19	1.65

<u>Variety</u>		5%	1%
1	16.0	}	}
3	15.5		
4	14.9		
2	12.9		

Height Analysis 1968Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	16.80	14.25	13.25	14.05	12.85	12.85	83.85	1,183.41		13.98
2	12.10	12.80	12.00	10.60	11.55	11.20	70.25	825.45		11.71
3	13.35	14.40	14.15	13.55	13.05	14.60	83.10	1,152.87		13.85
4	15.80	15.90	12.70	14.15	13.25	13.50	85.30	1,221.78		14.22
Totals(T)	58.05	57.35	52.10	52.35	50.70	51.95	322.50		4,357.93	

S.S. 856.51 827.07 681.08 693.59 644.39 680.87 4,383.51

T²/n 4,345.76

$$\text{Correction Factor} = \frac{322.50^2}{24} = 4,333.59$$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Table's</u>	
			5%	1%

$$\text{Total S.S.} = 4,383.51 - 4,333.59 = 49.92$$

23

$$\text{Between Vars.} = 4,357.93 - 4,333.59 = 24.34$$

3

8.11

9.11

3.29

5.42

$$\text{Between Reps.} = 4,345.76 - 4,333.59 = 12.17$$

5

2.43

2.73

$$\text{Error S.S.} = 13.41$$

15

0.89

$$\text{M.S.D.} = \sqrt{\frac{0.89 \times 2}{6}} = 0.55 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.131

2.947

1.17

1.62

<u>Variety</u>	5%	1%
4	14.22	}
1	13.98	
3	13.85	
2	11.71	1.62

Diameter Analysis 1968

Group VA

Var.	<u>Replication</u>						(T)		Average
	I	II	III	IV	V	VI	Totals	S.S.	
1	18.25	17.10	16.40	17.50	17.10	16.80	103.15	1,775.33	17.19
2	17.25	17.55	16.90	19.20	15.45	16.60	102.95	1,774.08	17.16
3	16.90	16.80	15.00	14.95	17.30	16.45	97.40	1,586.25	16.23
4	15.70	17.55	15.95	16.55	16.70	17.20	99.65	1,657.53	16.61
5	14.65	14.20	13.55	15.65	16.05	16.15	90.25	1,363.21	15.04
6	15.45	17.30	16.45	17.30	17.00	17.60	101.10	1,706.65	16.85
7	16.35	16.75	16.35	17.70	16.25	17.85	101.25	1,711.18	16.88

Total(T) 114.55 117.25 110.60 118.85 115.85 118.65 695.75 11,545.56

S.S. 1,883.37 1,972.15 1,755.50 2,029.80 1,919.96 2,013.45 11,574.23

T²/n 11,532.28

Correction Factor = $\frac{695.75^2}{42} = 11,525.43$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>		<u>F. from Tables</u>	
					5%	1%

Total S.S. = 11,574.23 - 11,525.43
= 48.80 41

Between Vars. = 11,545.56 - 11,525.43
= 20.13 6 3.36 4.60 2.42 3.47

Between Reps. = 11,532.28 - 11,525.43
= 6.85 5 1.37 1.88

Error S.S. = 21.82 30 0.73

M.S.D. = $\sqrt{\frac{0.73 \times 2}{6}} = 0.49$ x t at 5% and t at 1%

2.042	2.75
1.00	1.35

<u>Variety</u>		5%	1%
1	17.19	}	}
2	17.16		
7	16.88		
6	16.85		
4	16.61		
3	16.23	}	}
5	15.04		

Diameter Analysis 1967
Group VB

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	15.7	16.7	15.6	14.4	15.9	16.4	94.7	1,497.87		15.8
3	16.0	15.7	16.5	14.6	16.0	14.1	92.9	1,442.71		15.5
4	17.5	14.8	14.1	14.7	16.5	17.0	94.6	1,501.44		15.8
5	16.1	15.4	15.0	13.7	15.8	15.0	91.0	1,383.70		15.2
6	16.7	15.2	14.6	14.6	15.6	16.2	92.9	1,442.05		15.5
Total(T)	82.0	77.8	75.8	72.0	79.8	78.7	466.1		7,243.18	
S.S.	1,346.84	1,212.62	1,152.58	1,037.46	1,274.06	1,244.21		7,267.77		
T ² /n								7,253.64		

Correction Factor = $\frac{466.1^2}{30} = 7,241.64$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u> = 7,267.77 - 7,241.64 = 26.13	29				
<u>Between Vars.</u> = 7,243.18 - 7,241.64 = 1.54	4	0.39	0.62	2.87	4.43
<u>Between Reps.</u> = 7,253.64 - 7,241.64 = 12.00	5	2.40	3.81		
<u>Error S.S.</u> = 12.59	20	0.63			

Diameter Analysis 1968

Group VB

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	17.65	14.80	15.45	16.55	18.70	13.75	96.90	1,581.92	16.15	
2	9.85	11.40	9.75	10.50	10.05	11.85	63.40	673.72	10.57	
3	14.05	12.80	16.35	14.90	17.00	14.80	89.90	1,358.62	14.98	
4	17.05	16.05	14.60	18.00	16.70	15.40	97.80	1,601.52	16.30	
5	16.50	15.95	14.60	14.85	15.00	17.70	94.60	1,498.63	15.77	
6	16.40	15.85	16.00	15.15	15.90	15.60	94.90	1,501.88	15.82	
7	14.65	13.40	15.70	16.15	15.15	15.95	91.00	1,385.42	15.17	
Total(T)	106.15	100.25	102.45	106.10	108.50	105.05	628.50	9,548.70		
S.S.	1,652.48	1,455.63	1,529.90	1,641.03	1,725.92	1,596.74		9,601.71		
T ² /n								9,411.26		

Correction Factor = $\frac{628.50^2}{42} = 9,405.05$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 9,601.71 - 9,405.05
= 196.66

41

Between Vars. = 9,548.70 - 9,405.05
= 143.65

6

23.94

15.35

2.42

3.47

Between Reps. = 9,411.26 - 9,405.05
= 6.21

5

1.24

0.79

Error S.S. = 46.80

30

1.56

M.S.D. = $\sqrt{\frac{1.56 \times 2}{6}} = 0.72 \times t$ at 5% and t at 1%

2.042	2.750
1.47	1.98

<u>Variety</u>		5%	1%
4	16.30	}	}
1	16.15		
6	15.82		
5	15.77		
7	15.17		
3	14.98	}	}
2	10.57		

Diameter Analysis 1968Group VD

Var.	<u>Replication</u>						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	14.10	15.45	14.75	15.50	15.25	16.20	91.25	1,390.33		15.21
3	16.00	15.65	14.15	15.60	15.30	14.40	91.10	1,385.96		15.18
4	15.05	14.75	16.35	17.30	14.95	15.85	94.25	1,485.40		15.71
5	13.25	15.00	13.50	14.30	14.65	15.65	86.35	1,246.85		14.39
6	14.15	15.00	14.90	14.50	15.70	14.10	88.35	1,302.78		14.73
7	13.70	14.05	13.00	14.15	12.85	15.15	82.90	1,148.96		13.82
8	13.45	13.35	13.60	14.30	13.30	15.35	83.35	1,161.09		13.89
Total(T)	99.70	103.25	100.25	105.65	102.00	106.70	617.55		9,098.42	
S.S.	1,425.69	1,526.81	1,443.33	1,602.35	1,493.28	1,629.90		9,121.37		
T ² /n									9,085.93	

$$\text{Correction Factor} = \frac{617.55^2}{42} = 9,080.19$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

$$\text{Total S.S.} = 9,121.37 - 9,080.19 = 41.18$$

41

$$\text{Between Vars.} = 9,098.42 - 9,080.19 = 18.23$$

6

3.04

5.33

2.42

3.47

$$\text{Between Reps.} = 9,085.93 - 9,080.19 = 5.74$$

5

1.15

2.02

$$\text{Error S.S.} = 17.21$$

30

0.57

$$\text{M.S.D.} = \sqrt{\frac{0.57 \times 2}{6}} = 0.44 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

2.042

2.750

0.90

1.21

Variety

4	15.71
1	15.21
2	15.18
6	14.73
5	14.39
8	13.89
7	13.82

5%

1%

Diameter Analysis 1968

Group VE

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI	Totals			
1	19.90	17.70	16.25	15.35	18.95	18.45	106.60	1,908.49		17.77
2	16.90	16.80	18.90	18.75	17.45	16.80	105.60	1,863.37		17.60
3	13.55	14.95	14.45	16.65	16.35	14.85	90.80	1,380.98		15.13
4	15.00	15.00	14.00	17.10	17.05	16.90	95.05	1,514.72		15.84
5	17.45	16.10	17.15	17.20	16.95	17.60	102.45	1,750.74		17.08
6	17.60	15.10	14.50	16.60	16.25	16.40	96.45	1,556.60		16.08
Total(T)	100.40	95.65	95.25	101.65	103.00	101.00	596.95		9,932.11	
S.S.	1,704.49	1,531.25	1,530.45	1,728.22	1,773.00	1,707.50			9,974.91	
T ² /n									9,907.40	

Correction Factor = $\frac{596.95^2}{36} = 9,898.59$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
Total S.S. = 9,974.91 - 9,898.59 = 76.32	35				
<u>Between Vars.</u> = 9,932.11 - 9,898.59 = 33.52	5	6.70	4.93	2.60	3.86
<u>Between Reps.</u> = 9,907.40 - 9,898.59 = 8.81	5	1.76	1.29		
<u>Error S.S.</u> = 33.99	25	1.36			
<u>M.S.D.</u> = $\sqrt{\frac{1.36 \times 2}{6}} = 0.67 \times t$ at 5% and t at 1%				2.06	2.79
				1.38	1.87

<u>Variety</u>	5%	1%
1	17.77	}
2	17.60	
5	17.08	}
6	16.08	
4	15.84	}
3	15.13	

Diameter Analysis 1967
Group VF

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	17.6	18.1	17.8	18.7	16.3	16.6	105.1	1,845.15		17.5
2	16.7	17.2	18.3	15.9	17.6	18.2	103.9	1,803.43		17.3
3	16.1	16.5	15.5	17.3	18.6	15.4	99.4	1,654.12		16.6
4	16.9	17.0	17.1	17.3	15.8	16.3	100.4	1,681.64		16.7
Total(T)	67.3	68.8	68.7	69.2	68.3	66.5	408.8		6,966.96	
S.S.	1,133.47	1,184.70	1,184.39	1,201.08	1,171.05	1,109.65		6,984.34		
T ² /n									6,964.55	

Correction Factor = $\frac{408.8^2}{24} = 6,963.23$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u> = 6,984.34 - 6,963.23 = 21.11	23				
<u>Between Vars.</u> = 6,966.96 - 6,963.23 = 3.73	3	1.24	1.16	3.29	5.42
<u>Between Reps.</u> = 6,964.55 - 6,963.23 = 1.32	5	0.26	0.24		
<u>Error S.S.</u> = 16.06	15	1.07			

Diameter Analysis 1968Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI	Totals			
1	15.60	14.85	15.95	14.60	14.15	15.15	90.30	1,361.19	15.05	
2	14.85	14.50	15.40	13.80	13.75	14.00	86.30	1,243.44	14.38	
3	14.45	15.65	15.15	14.85	14.90	15.10	90.10	1,353.79	15.02	
4	15.75	15.00	15.50	15.75	15.20	13.80	91.00	1,382.86	15.17	
Total(T)	60.65	60.00	62.00	59.00	58.00	58.05	357.70		5,333.47	

S.S. 920.75 900.70 961.34 872.19 842.34 843.97 5,341.29

T²/n 5,334.31

$$\text{Correction Factor} = \frac{357.70^2}{24} = 5,331.22$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u> = 5,341.29 - 5,331.22 = 10.07	23				
<u>Between Vars.</u> = 5,333.47 - 5,331.22 = 2.25	3	0.75	2.34	3.29	5.42
<u>Between Reps.</u> = 5,334.31 - 5,331.22 = 3.09	5	0.62	1.94		
<u>Error S.S.</u> = 4.73	15	0.32			

Height: Diameter Ratio of Bulbs 1967
Group VA

Var.	Replication						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.76	0.73	0.78	0.66	0.76	0.72	4.41	3.25	22.07	0.74
2	0.87	0.74	0.74	0.67	0.67	0.70	4.39	3.24		0.73
4	0.72	0.75	0.81	0.67	0.76	0.76	4.47	3.34		0.75
5	1.07	0.96	0.90	1.04	0.89	1.14	6.00	6.05		1.00
6	0.69	0.72	0.70	0.67	0.65	0.72	4.15	2.87		0.69
7	0.79	0.89	0.75	0.65	0.71	0.74	4.53	3.45		0.76
Totals (T)	4.90	4.79	4.68	4.36	4.44	4.78	27.95			
S.S.	4.10	3.88	3.67	3.29	3.32	3.95		22.21		
T ² /n								21.74		

Correction Factor = $\frac{27.95^2}{36} = 21.70$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Totals S.S.</u> = 22.21 - 21.70 = 0.51	35				
<u>Between Vars.</u> = 22.07 - 21.70 = 0.37	5	0.074	18.50	2.60	3.86
<u>Between Reps.</u> = 21.74 - 21.70 = 0.04	5	0.008	2.00		
<u>Error S.S.</u> = 0.10	25	0.004			
<u>M.S.D.</u> = $\sqrt{\frac{0.004 \times 2}{6}}$ = 0.036 x t at 5% and t at 1%					
			2.06	2.79	
			0.07	0.10	

Variety	5%	1%
5	1.00	
7	0.76	
4	0.75	
1	0.74	
2	0.73	
6	0.69	

Height: Diameter Ratio of Bulbs 1968
Group VA

Var.	<u>Replication</u>						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.80	0.66	0.79	0.71	0.71	0.77	4.44	3.30	26.81	0.74
2	0.69	0.74	0.74	0.67	0.86	0.81	4.51	3.42		0.75
3	0.76	0.81	0.90	0.83	0.68	0.74	4.72	3.74		0.79
4	0.80	0.71	0.75	0.79	0.79	0.79	4.63	3.58		0.77
5	1.02	0.98	1.04	0.97	1.07	0.90	5.98	5.98		0.99
6	0.80	0.67	0.68	0.80	0.75	0.78	4.48	3.36		0.75
7	0.78	0.77	0.74	0.78	0.86	0.68	4.61	3.56		0.77
							33.37	26.94		
<u>Totals</u>	5.65	5.34	5.64	5.55	5.72	5.47	33.37			
<u>S.S.</u>	4.62	4.15	4.64	4.46	4.78	4.30		26.95		
<u>T²/n</u>									26.53	

Correction Factor = $\frac{33.37^2}{42} = 26.51$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u> = 26.95 - 26.51 = 0.44	41				
<u>Between Vars.</u> = 26.81 - 26.51 = 0.30	6	0.05	12.50	2.42	3.47
<u>Between Reps.</u> = 26.53 - 26.51 = 0.02	5	0.004	1.00		
<u>Error S.S.</u> = 0.12	30	0.004			
<u>M.S.D.</u> = $\sqrt{\frac{0.004 \times 2}{6}}$		0.036			
				2.042	2.750
				0.07	0.10

<u>Varieties</u>		5%	1%
5	0.99	-	-
3	0.79	}	}
4	0.77		
7	0.77		
2	0.75		
6	0.75		
1	0.74		

Height: Diameter Ratio of Bulbs 1967

Group VB

Var.	Replication						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.76	0.81	0.83	0.68	0.75	0.77	4.60	3.54	0.77	
3	0.91	1.01	0.92	0.96	0.82	0.90	5.52	5.10	0.92	
4	0.92	1.06	0.99	0.89	0.88	0.83	5.57	5.21	0.93	
5	0.97	1.03	1.03	1.14	0.91	1.12	6.20	6.44	1.03	
6	0.76	0.80	0.81	0.83	0.77	0.76	4.73	3.73	0.79	
Totals (T)	4.32	4.71	4.58	4.50	4.13	4.38	26.62			
S.S.	3.77	4.50	4.23	4.16	3.43	3.92		24.02		
T ² /n									23.66	

Correction Factor = $\frac{26.62^2}{30} = 23.62$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Total S.S.</u>	29	0.40			
<u>Between Vars.</u>	4	0.073	18.25	2.87	4.43
<u>Between Reps.</u>	5	0.008	2.00		
<u>Error S.S.</u>	20	0.004			
<u>M.S.D.</u>		$\sqrt{\frac{0.004 \times 2}{6}} = 0.036$			
				t at 5%	t at 1%
				2.086	2.845
				0.071	0.10

Variety	5%	1%
5	1.03	-
4	0.93	}
3	0.92	}
6	0.79	}
1	0.77	}

Height: Diameter Ratio of Bulb 1968

Group VB

Var.	Replication						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.74	0.85	0.71	0.83	0.65	1.04	4.82	3.97		0.80
2	1.99	1.95	2.33	2.05	2.28	2.05	12.65	26.79		2.11
3	1.22	1.40	0.98	1.08	0.93	1.00	6.61	7.44		1.10
4	0.94	1.07	1.15	0.91	0.94	1.08	6.09	6.23		1.02
5	1.05	0.94	0.86	1.08	1.15	0.91	5.99	6.04		0.99
6	0.72	0.82	0.67	1.10	0.73	0.88	4.92	4.16		0.82
7	1.07	1.18	1.00	0.98	1.13	0.99	6.35	6.75		1.06
							47.43	61.37	60.74	
<u>Totals</u>	7.73	8.21	7.70	8.03	7.81	7.95	47.43			
<u>S.S.</u>	9.65	10.58	10.40	10.22	10.50	10.03		61.38		
<u>T²/n</u>									53.59	

Correction Factor = $\frac{47.43^2}{42} = 53.56$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Total S.S.</u> = 61.38 - 53.56 = 7.82	41				
<u>Between Vars.</u> = 60.74 - 53.56 = 7.18	6	1.20	60.00	2.42	3.47
<u>Between Reps.</u> = 53.59 - 53.56 = 0.03	5	0.006	0.30		
<u>Error S.S.</u> = 0.61	30	0.02			
<u>M.S.D.</u> = $\sqrt{\frac{0.02 \times 2}{6}}$ = 0.082 x t at 5% and t at 1%.					
				2.042	2.750
				0.17	0.23

Varieties	5%	1%
2	2.11	-
3	1.10	-
7	1.06	-
4	1.02	-
5	0.99	-
6	0.82	-
1	0.80	-

Height: Diameter Ratio of Bulbs 1967
Group VC

Var.	Replication						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	1.01	0.92	0.77	0.98	0.93	0.91	5.52	5.11		0.92
2	0.78	0.72	0.85	0.72	0.80	0.72	4.59	3.53		0.77
3	1.22	1.22	1.14	1.10	1.23	1.12	7.03	8.25		1.17
4	1.30	1.09	1.00	1.20	1.03	1.12	6.74	7.63		1.12
5	1.01	1.00	1.09	0.92	0.90	0.86	5.78	5.60		0.96
6	0.80	0.85	0.94	0.82	0.87	0.87	5.15	4.43		0.86
7	1.81	1.89	2.66	2.01	2.36	2.26	12.99	28.64		2.17
8	2.46	2.49	2.76	2.58	2.46	2.49	18.24	38.78	101.22	2.54
Totals	10.39	10.18	11.21	10.33	10.58	10.38	63.04			
S.S.	15.79	15.54	20.38	16.34	17.27	16.66		101.97		
T ² /n								82.88		

$$\text{Correction Factor} = \frac{63.04^2}{48} = 82.79$$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Total S.S.</u> = 101.97 - 82.79 = 19.18	47				
<u>Between Vars.</u> = 101.22 - 82.79 = 18.43	7	2.63	131.50	2.30	3.21
<u>Between Reps.</u> = 82.88 - 82.79 = 0.09	5	0.02	1.00		
<u>Error S.S.</u> = 0.66	35	0.02			
<u>M.S.D.</u> = $\sqrt{\frac{0.02 \times 2}{6}}$ = 0.082 x t at 5% and t at 1%					
				2.03	2.72
				0.17	0.22

Variety	5%	1%
8	2.54	-
7	2.17	-
3	1.17	-
4	1.12	-
5	0.96	-
1	0.92	-
6	0.86	-
2	0.77	-

Height: Diameter Ratio of Bulb 1968
Group VC

Var.	Replication						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.98	0.95	1.04	0.82	0.93	0.93	5.65	5.35	0.94	
2	0.90	0.88	0.97	0.92	0.89	0.91	5.47	4.99	0.91	
3	1.18	1.33	1.39	1.21	1.05	1.21	7.37	9.12	1.23	
4	1.29	1.43	1.48	0.81	1.35	1.46	7.82	10.51	1.30	
5	0.95	1.04	1.02	0.98	0.90	1.06	5.95	5.92	0.99	
6	0.92	1.06	1.00	1.01	0.97	0.94	5.90	5.81	0.98	
7	1.94	2.34	2.53	2.18	1.94	2.21	13.14	29.04	2.19	
8	2.10	2.23	2.33	2.18	2.12	2.60	13.56	30.82	2.26	
							64.86	101.56	100.68	
<u>Totals</u>	10.26	11.26	11.76	10.11	10.15	11.32	64.86			
<u>S.S.</u>	14.75	18.14	20.02	15.12	14.59	18.94		101.56		
<u>T²/n</u>									87.97	

$$\text{Correction Factor} = \frac{64.86^2}{48} = 87.64$$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables
			5%	1%
<u>Total S.S.</u>	= 101.56 - 87.64 = 13.92	47		
<u>Between Vars.</u>	= 100.68 - 87.64 = 13.04	7	1.86	93.00
			2.30	3.21
<u>Between Reps.</u>	= 87.97 - 87.64 = 0.33	5	0.07	3.50
<u>Error S.S.</u>	= 0.55	35	0.02	
<u>M.S.D.</u>	= $\sqrt{\frac{0.02 \times 2}{6}}$		0.082	t at 5% and t at 1%
			2.03	2.72
			0.17	0.22

Varieties	5%	1%
8	2.26	
7	2.19	
4	1.30	
3	1.23	
5	0.99	
6	0.98	
1	0.94	
2	0.91	

Height: Diameter Ratio of Bulbs 1968

Group VD

Var.	<u>Replication</u>						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.87	0.84	0.81	0.72	0.77	0.78	4.79	3.84	32.78	0.80
3	0.80	0.70	0.95	0.77	0.78	0.88	4.88	4.01		0.81
4	0.84	0.83	0.80	0.75	0.82	0.85	4.89	3.99		0.82
5	1.00	0.89	1.04	0.87	0.94	0.80	5.54	5.15		0.92
6	0.96	0.93	0.94	0.83	0.88	0.95	5.49	5.04		0.92
7	0.82	0.92	1.04	0.89	0.89	0.84	5.40	4.89		0.90
8	1.05	0.88	1.21	0.85	1.14	0.87	6.00	6.12		1.00
<u>Totals</u>	6.34	5.99	6.79	5.68	6.22	5.97	36.99			
<u>S.S.</u>	5.80	5.16	6.71	4.63	5.62	5.11		33.04		
<u>T²/n</u>									32.68	

Correction Factor = $\frac{36.99^2}{42} = 32.58$

		<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
					5%	1%
<u>Total S.S.</u>	= 33.04 - 32.58 = 0.46	41				
<u>Between Vars.</u>	= 32.74 - 32.58 = 0.16	6	0.03	4.29	2.42	3.47
<u>Between Reps.</u>	= 32.68 - 32.58 = 0.10	5	0.02	2.86		
<u>Error S.S.</u>	= 0.20	30	0.007			
<u>M.S.D.</u>	= $\sqrt{\frac{0.007 \times 2}{6}}$					
	= 0.05 x t at 5% and t at 1%					
				2.042	2.750	
				0.10	0.14	

<u>Varieties</u>		<u>5%</u>	<u>1%</u>
8	1.00	}	}
6	0.92		
5	0.92		
7	0.90		
4	0.82		
3	0.81		
1	0.80		

Height: Diameter Ratio of Bulbs 1968Group VEReplication

Var.	I	II	III	IV	V	VI	Totals	S.S.	T ² /n	Average
1	0.74	0.77	0.72	0.93	0.82	0.83	4.81	3.89		0.80
2	0.71	0.50	0.51	0.43	0.46	0.50	3.11	1.66		0.52
3	1.09	1.04	1.00	0.91	0.89	1.11	6.04	6.12		1.01
4	0.94	0.88	0.98	0.90	0.77	0.80	5.27	4.66		0.88
5	0.94	0.90	0.80	0.93	0.71	0.76	5.04	4.28		0.84
6	0.85	1.00	0.89	0.88	0.78	0.86	5.26	4.64		0.88
							29.53		25.02	
<u>Totals</u>	5.27	5.09	4.90	4.98	4.43	4.86	29.53			
<u>S.S.</u>	4.73	4.51	4.17	4.33	3.38	4.13		25.25		
<u>T²/n</u>									24.29	

$$\text{Correction Factor} = \frac{29.53^2}{36} = 24.22$$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

$$\text{Total S.S.} = 25.25 - 24.22 = 1.03 \quad 35$$

$$\text{Between Vars.} = 25.02 - 24.22 = 0.80 \quad 5 \quad 0.16 \quad 16.00 \quad 2.60 \quad 3.86$$

$$\text{Between Reps.} = 24.29 - 24.22 = 0.07 \quad 5 \quad 0.01 \quad 1.00$$

$$\text{Error S.S.} = 0.26 \quad 25 \quad 0.01$$

$$\text{M.S.D.} = \sqrt{\frac{0.01 \times 2}{6}} = 0.054 \times t \text{ at } 5\% \text{ and } t \text{ at } 1\%$$

	2.06	2.79
	0.12	0.17

<u>Variety</u>		<u>5%</u>	<u>1%</u>
3	1.01	}	}
4	0.88		
6	0.88		
5	0.84		
1	0.80	}	}
2	0.52		

Height: Diameter Ratio of Bulbs 1967

Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	0.88	0.80	1.01	0.86	1.01	1.08	5.64	5.36	0.94	
2	0.73	0.80	0.74	0.82	0.72	0.73	4.54	3.44	0.76	
3	1.00	0.89	0.99	1.00	0.83	1.07	5.78	5.61	0.96	
4	0.92	0.84	0.81	0.93	0.94	1.02	5.46	5.00	0.91	
Totals(T)	3.53	3.33	3.55	3.61	3.50	3.90	21.42			
S.S.	3.15	2.78	3.20	3.28	3.11	3.88		19.41		
T ² /n									19.16	

Correction Factor = $\frac{21.42^2}{24} = 19.12$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F, by Calculation</u>	<u>F, from Tables</u>	
			x	5%	1%
<u>Total S.S.</u>	= 19.41 - 19.12 = 0.29	23			
<u>Between Vars.</u>	= 19.27 - 19.12 = 0.15	3	0.050	7.14	3.29
<u>Between Reps.</u>	= 19.16 - 19.12 = 0.04	5	0.008	1.14	5.42
<u>Error S.S.</u>	= 0.10	15	0.007		
<u>M.S.D.</u>	= $\sqrt{\frac{0.007 \times 2}{6}} = 0.048 \times t$ at 5% and t at 1%				
				2.131	2.947
				0.102	0.141

<u>Variety</u>		5%	1%
3	0.96	}	}
1	0.94		
4	0.91		
2	0.76	-	-

Height: Diameter Ratio of Bulb 1968
Group VF

Var.	Replication						Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	1.09	0.98	0.84	1.00	0.94	0.85	5.70	5.46	0.95	
2	0.82	0.88	0.79	0.77	0.85	0.81	4.92	4.04		
3	0.93	0.95	0.97	0.93	0.89	0.98	5.65	5.33		
4	1.04	1.10	0.83	0.92	0.88	1.00	5.77	5.60		
							22.04	20.43	20.32	
<u>Totals</u>	3.88	3.91	3.43	3.62	3.56	3.64	22.04			
<u>S.S.</u>	3.81	3.85	2.96	3.30	3.17	3.34		20.43		
<u>T²/n</u>								20.29		

$$\text{Correction Factor} = \frac{22.04^2}{24} = 20.24$$

	Degrees of Freedom	Variance	F _o by Calculation	F _o from Tables	
				5%	1%
<u>Total S.S.</u> = 20.43 - 20.24 = 0.19	23				
<u>Between Vars.</u> = 20.32 - 20.24 = 0.08	3	0.03	7.50	3.29	5.42
<u>Between Reps.</u> = 20.29 - 20.24 = 0.05	5	0.01	2.25		
<u>Error S.S.</u> =	0.06	15	0.004		
<u>M.S.D.</u> = $\sqrt{\frac{0.004 \times 2}{6}}$ = 0.036 x t at 5% and t at 1%					
			2.131	2.947	
			0.08	0.11	

Varieties		5%	1%
4	0.96	}	}
1	0.95		
3	0.94		
2	0.82		

Foliage Height 1968Group VA

Var.	<u>Replication</u>						(T)		T ² /n	Average
	I	II	III	IV	V	VI	Totals	S.S.		
1	50.8	47.7	49.2	45.9	45.5	55.3	294.4	14,511.72	49.07	
2	56.1	51.4	49.6	47.9	42.9	51.1	299.0	14,995.36	49.83	
3	50.5	45.4	50.0	48.5	52.4	46.0	292.8	14,325.42	48.80	
4	51.1	54.4	51.2	46.3	48.6	43.3	294.9	14,572.55	49.15	
5	59.7	56.8	55.6	45.6	51.7	52.5	321.9	17,390.19	53.65	
6	49.7	47.6	52.4	48.9	43.5	46.8	288.9	13,955.31	48.15	
7	55.3	52.7	49.4	46.8	45.4	46.1	295.7	14,652.35	49.28	

Totals(T) 373.2 356.0 357.4 329.9 330.0 341.1 2,087.6 103,881.92

S.S. 19,981.58 18,207.06 18,279.72 15,557.97 15,644.68 16,731.89 104,402.90

T²/n 103,976.03

Correction Factor = $\frac{2087.6^2}{42}$ = 103,763.66

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%

Total S.S. = 104,402.90 - 103,763.66
= 639.24 41

Between Vars. = 103,881.92 - 103,763.66
= 118.26 6 19.71 1.92 2.42 3.47

Between Reps. = 103,976.03 - 103,763.66
= 212.37 5 42.47 4.13

Error S.S. = 308.61 30 10.29

Foliage Height 1968Group VB

Var.	<u>Replication</u>						(T)		Average
	I	II	III	IV	V	VI	Totals	S.S.	
1	62.1	60.5	61.2	63.5	53.1	50.1	350.5	20,623.97	58.42
2	66.5	68.3	60.9	59.6	54.0	50.8	360.1	21,844.75	60.02
3	68.5	56.9	61.9	62.1	55.3	51.1	355.8	21,287.18	59.30
4	60.2	64.4	56.3	63.3	52.8	55.1	352.1	20,771.83	58.68
5	65.0	60.3	60.2	56.0	55.1	52.8	349.4	20,444.98	58.23
6	67.6	60.1	62.7	57.5	57.5	53.8	359.2	21,620.00	59.87
7	69.3	62.4	64.9	62.1	50.3	58.6	367.6	22,728.72	61.27
(T)									148,220.84
Totals	459.2	432.9	428.1	424.1	378.1	372.3	2,494.7		
S.S.	30,192.20	26,851.97	26,222.89	25,747.37	20,453.89	19,851.11		149,321.43	
T ² /n								148,994.91	

$$\text{Correction Factor} = \frac{2,494.7^2}{42} = 148,179.20$$

	<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
				5%	1%
<u>Total S.S.</u> = 149,321.43 - 148,179.20 = 1,142.23	41				
<u>Between Vars.</u> = 148,220.84 - 148,179.20 = 41.64	6	6.94	0.73	2.42	3.47
<u>Between Reps.</u> = 148,994.91 - 148,179.20 = 815.71	5	163.14	17.17		
<u>Error S.S.</u> = 284.88	30	9.50			

Foliage Height 1968

Group VC

Var.	<u>Replication</u>						(T) Totals	S.S.	T ² /n	Average
	I	II	III	IV	V	VI				
1	53.7	49.1	45.9	50.9	48.2	44.8	292.6	14,322.40		48.77
2	52.2	48.3	54.4	51.7	45.7	45.6	297.9	14,857.83		49.65
3	60.9	57.6	50.9	47.5	50.4	41.8	309.1	16,161.03		51.52
4	55.3	56.1	57.9	47.6	47.8	45.0	309.7	16,133.31		51.62
5	52.1	50.4	53.1	49.1	46.9	46.4	298.0	14,837.56		49.67
6	62.2	56.3	52.8	56.3	56.5	54.8	338.9	19,191.35		56.48
7	53.4	53.3	44.6	47.0	49.6	45.2	293.1	14,393.81		48.85
8	46.8	51.9	43.0	41.8	44.7	38.0	266.2	11,922.18		44.37

(T) Totals 436.6 423.0 402.6 391.9 389.8 361.6 2,405.5 121,040.55

S.S. 24,000.48 22,453.02 20,455.0 19,322.45 19,086.84 16,501.68 121,819.47

T²/n 120,989.94

Correction Factor = $\frac{2,405.5^2}{48} = 120,550.63$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 121,819.47 - 120,550.63
= 1,268.84 47

Between Vars. = 121,040.55 - 120,550.63
= 489.92 7 69.98 7.21 2.30 3.21

Between Reps. = 120,988.94 - 120,550.63
= 439.31 5 87.86 9.06

Error S.S. = 339.61 35 9.70

M.S.D. = $\sqrt{\frac{9.70 \times 2}{6}} = 1.80 \times t$ at 5% and t at 1%

	2.03	2.72
	3.65	4.90

<u>Variety</u>	5%	1%
6	56.48	
4	51.62	
3	51.52	
5	49.67	
2	49.65	
7	48.85	
1	48.77	
8	44.37	

Foliage Height 1968Group VE

Var.	<u>Replication</u>						(T)		T ² /n	Average
	I	II	III	IV	V	VI	Totals	S.S.		
1	43.8	42.8	36.8	36.8	41.3	38.1	239.6	9,616.06	39.93	
2	28.0	24.3	28.0	25.1	25.6	26.0	157.0	4,119.86	26.17	
3	61.1	51.3	47.3	48.3	50.0	47.6	305.6	15,700.84	50.93	
4	42.8	35.3	39.9	37.8	34.5	35.7	226.0	8,563.52	37.67	
5	50.6	49.2	53.4	48.8	50.9	51.6	304.5	15,467.37	50.75	
6	50.7	52.5	52.5	48.1	47.4	49.3	300.5	15,073.85	50.08	
Totals(T)	277.0	255.4	257.9	244.9	249.7	248.3	1,533.2		68,257.50	
S.S.	13,398.34	11,477.00	11,575.35	10,441.03	10,888.87	10,760.91		68,541.50		
T ² /n								65,408.26		

$$\text{Correction Factor} = \frac{1,533.2^2}{36} = 65,297.28$$

	Degrees of Freedom	Variance	F. by Calculation	F. from Tables	
				5%	1%
<u>Total S.S.</u> = 68,541.50 - 65,297.28 = 3,244.22	35				
<u>Between Vars.</u> = 68,257.50 - 65,297.28 = 2,960.22	5	592.04	85.55	2.60	3.86
<u>Between Reps.</u> = 65,408.26 - 65,297.28 = 110.98	5	22.20	3.21		
<u>Error S.S.</u> = 173.02	15	16.72			

Foliage Height 1968Group VF

Var.	<u>Replication</u>						(T)	S.S.	T ² /n	Average
	I	II	III	IV	V	VI	Totals			
1	52.6	54.7	57.5	46.4	49.7	53.4	314.5	16,562.75	52.42	
2	58.9	48.2	52.8	58.0	55.0	54.9	327.8	17,983.30	54.63	
3	61.3	59.7	55.8	53.8	52.8	51.1	334.5	18,728.91	55.75	
4	58.8	51.5	61.7	46.5	54.8	50.0	323.3	17,581.87	53.88	
Totals(T)	231.6	214.1	228.0	204.7	212.3	209.4	1,300.1		70,462.70	

S.S. 13,451.10 11,531.67 13,037.66 10,573.65 11,25.97 10,976.78 70,856.83

T²/n 70,570.77

$$\text{Correction Factor} = \frac{1,300.1^2}{24} = 70,427.50$$

<u>Degrees of Freedom</u>	<u>Variance</u>	<u>F. by Calculation</u>	<u>F. from Tables</u>	
			5%	1%

Total S.S. = 70,856.83 - 70,427.50
= 429.33

23

Between Vars. = 70,462.70 - 70,427.50
= 35.20

3

11.73

0.70

3.29

5.42

Between Reps. = 70,570.77 - 70,427.50
= 143.27

5

28.65

1.71

Error S.S. = 250.86

15

16.72

