



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

C. F. C. S.

**ASSOCIATION INTER-CARAÏBE DES PLANTES ALIMENTAIRES
CARIBBEAN FOOD CROPS SOCIETY**

**COMPTES RENDUS — SEPTIÈME CONGRÈS ANNUEL
PROCEEDINGS — SEVENTH ANNUAL MEETING**

Martinique — Guadeloupe

1969

VOLUME VII

A STUDY OF VARIABILITY IN YAMS (*DIOSCOREA SPP.*)

T. U. FERGUSON, P. H. HAYNES & B. G. F. SPRINGER

Faculty of Agriculture, The University of the West Indies, Trinidad, W. I.

INTRODUCTION

In agriculture a characteristic of all experimental material is variation. Experimental error is a measure of the variation which exists among observations on experimental units treated alike. When expressed on a relative basis for the whole experiment it is the coefficient of variation.

Variation comes from two main sources :

a) Genetic or inherent variation. This exists in the experimental material to which treatments are to be applied.

b) Environmental variation. This results from the lack of uniformity introduced in the conducting of an experiment.

The contribution of these sources of variation differs between plants. Some plants, such as the cereals, are very uniform and thus genetic variability is relatively low. The coefficient of variation for experiments on wheat is generally very low (see Table below). Other crops, such as fruit trees, have a high inherent variability which is partly responsible for the high coefficients of variation normally observed. It must, however, be borne in mind that the number of plants per plot also affects the coefficient of variation.

*Approximate range of coefficient of variation
recorded for some crops.
Adapted from Smith (1938)*

Crop	Plot Size (Sq. Ft.)		
	100	500	2 000
Wheat	10-15 %	5-12 %	5-6 %
Maize	c. a. 15 %	10-18 %	8-15 %
Cotton	—	c. a. 35 %	7-15 %
Fruit Trees	—	15-90 %	10-70 %

In any experiment it is important that every effort be made to reduce experimental error and thus the coefficient of variation in order to improve the power of a test. This, as stated by STEEL and TORRIE (1960), can be accomplished by considering the two main sources of experimental error. Thus we can :

1) Handle the experimental material so that the effects of inherent variability are reduced.

2) Refine experimental technique.

A limited number of experiments have been conducted on yams. For many of these little or no statistical data are presented. Where statistical data are presented the coefficient of variability is relatively high (25-58 %) — (CHAPMAN, 1965 ; KASASIAN and SEEYAVE, 1967 ; SEEYAVE, 1968). This indicates a low degree of precision in these experiments. It is also known that many trials were conducted which either were not published or very briefly reported because of poor results.

Many workers have tried to overcome this variability by using very large experimental plots. IRVING (1956) in Nigeria used plots of 1/10 of an acre (4,356 sq. ft.) and GOODING and HOAD (1967) in Barbados have used plots up to 1/6 of an acre (7,260 sq. ft.). Increasing plot size generally increases the precision of an experiment but under very heterogeneous soil conditions this may not apply. The size of experiments with yams using large plots are of the order of 2-4 acres. The availability of such large uniform experimental sites is not always possible. This, in addition to the high cost, makes large plot sizes undesirable.

The magnitude of the different sources of variation in yams is not clear. Undoubtedly, poor experimental technique contributes to the low precision of some experiments ; however, the contribution from highly variable planting pieces, poor choice of treatments and bad experimental design may be more important. MEIGE (1957) found that the size of the mother tuber from which the planting piece is taken and its position on the mother tuber (head, middle or tail) can affect the yield of the resulting plant.

It is the object of this paper to :

1) Estimate the magnitude of inherent variability.

2) Try to suggest ways for handling the experimental material such that the effects of inherent variability are reduced.

EXPERIMENTAL PROCEDURE

As a preliminary to a more detailed study, a series of observations were made in a commercial field of White Lisbon yam (*D. alata*) at the Texaco Food Crops Demonstration Farm, Trinidad. In the commercial field 4 oz. setts were planted at a spacing of 18 inches on ridges spaced 27 inches apart. The planting material was a mixture of heads, middles, tails and whole tubers. Three hundredweight per acre of Triple Super Phosphate and Muriate of Potash were applied at planting and two and a half hundredweight of Sulphate of Ammonia at 3 months. They were staked using the system of

slung wires (HAYNES 1967). Atrazine at 3 lbs. per acre was used as a pre-emergence herbicide and paraquat at 2 pints per acre when required.

Ten groups of 12 plants along a row were selected randomly over the field. Observations were made on the spacing between plants, the number of plants producing tubers, the number of tubers per plant, the weight of tubers per plant and the weight of individual tubers.

In the main study a range of planting material for White Lisbon (*D. alata*), Chinese (*D. esculenta*) and Cush-Cush (*D. trifida*) were compared. There were 12 treatments, the details of which are given in Table 1 in the Appendix.

Two sizes of *D. esculenta* were included because size was the only variation in the planting materials available. A randomised block design was used. There were 3 replications. These were spaced at 18 inches on ridges 3 feet apart. The plots were 21 feet \times 15 feet giving 70 plants per plot. The trial was not fertilized. A pre-emergence application of atrazine at 3 lbs. per acre was applied. Subsequent weedings were by hand. Records were kept on rates of germination, stem number per plant, number of tubers per plant and the weight of tubers per plant.

RESULTS AND DISCUSSION

Both tuber number and tuber weight showed considerable variability as indicated by the generally high coefficient of variation between the plants within the various groups (Table 2). The relative differences in variance between the various groups are higher for tuber weight than for tuber number. Thus for tuber number the highest variance (34.7) observed is only 6 times greater than the lowest (5.5), whereas for tuber weight the highest variance (167.99) is about 56 times that of the lowest (2.97). The greater variability for tuber weight is reflected in a higher coefficient of variation of 58.8 % between groups.

The differences in variance between groups of plants may be attributed to variation in soil conditions because the groups were taken at random over a large field. However, the variation within the groups in the tuber number and yield of individual plants spaced only 18 inches apart could be due mainly to inherent variability in the planting material which was further aggravated by inter-plant competition. The planting material in this study was a mixture of heads, middles, tails and whole tubers. FERGUSON (1969) showed that there are significant differences between heads, middles and tails for nitrogen, potassium and calcium content. He also demonstrated that the percentage dry matter, and thus the total supply of carbohydrates to the young plant are significantly different for the different types. Differences in growth, especially in the early stages can thus be expected between the various types. MEIGE (1957) and GOODING and HOAD (1967) have shown that heads germinate before middles and tails. Some workers have found that heads give a higher yield than middles and tails but GOODING and HOAD (1967) and FERGUSON and HAYNES (1969) did not find so.

MEIGE (1957) looked at the effect of the weight of the parent tuber on yield and found that planting material taken from small tubers (600 gms.) germinated earlier and gave higher yields than that taken from larger tubers. The weight of the parent tuber could, therefore, be another source of variation. The main trial was designed with these factors in mind.

In this study heads germinated earlier than middles and tails. There was severe rotting of the pieces in the *D. trifida* treatments, presumably because the exposed surface allowed for rapid decomposition. Ninety-three percent of the whole tubers germinated whereas only fifty-two percent and sixty-one percent of the heads and tails, respectively, germinated. There was almost one hundred percent germination in all other treatments.

The differences observed for stem number, tuber number and yield were mainly due to that between species (Table 3). Tails taken from small tubers of *D. alata* produced significantly more stems than heads and middles from large tubers. Heads and tails taken from small tubers produced a larger number of tubers than heads and middles of large tubers. Pieces taken from small tubers thus seem to give a larger stem number and tuber number than those taken from larger tubers. There were no significant differences in the yield of *D. alata* treatments even when they were considered separately.

The homogeneity of the variance between the various treatments was examined using BARTLETT'S (1937) test and the results given in Table 4 *a*, *b* and *c*.

The variance of the stem number was not homogeneous between the treatments and this seems to be mainly due to differences between the species. When the test is applied to tuber number they also group into species. Within the *D. alata* treatments, however, the weight of the mother tuber seems to have some effect on the variance. Heads and middles from mother tubers over 24 ozs. (680 gms) have significantly lower variances than heads and tails from mother tubers of 8-16 ozs (227-454 gms). It therefore appears that pieces from large tubers give rise to plants which are less variable in tuber number. The type of planting material affected the variance of the tuber yield. The variances grouped roughly by type although there was some overlapping of confidence limits. Variance seems to increase from whole tubers through tails, middles and heads to aerial tubers.

An analysis of variance is only valid when the variance of the various treatments is homogeneous. The results indicate that the tuber number of planting pieces taken from different sizes mother tubers and the tuber yield of different types of planting material are not homogeneous in variance. The analysis of variance therefore appears not to be valid. It is quite likely that differences between treatments may be more significant than indicated above. In the next stage of this work we will be investigating various methods for handling such experimental data.

The contradicting results of the effect of the type of planting material on yield were discussed earlier. In the light of the above observation the analysis of these experiments may not be valid and differences observed may be significant.

In the preliminary study high coefficients of variation were observed between plants in groups. In this study high coefficients of variation were also observed within the plots of a single type of planting material even though as much as seventy plants per plot were used. This high variation thus appears to be a characteristic of the crop and can be taken as a measure of inherent variation.

The coefficients of variation recorded for the whole experiment were 18.04 %, 18.48 % and 23.30 % for stem number, tuber number and tuber weight respectively. The higher coefficients for tuber weight indicate a higher degree of variation in tuber yield. FERGUSON and HAYNES (1969) recorded a low coefficient of variation of 11 % for a field experiment on *D. alata*. This experiment was a $3 \times 2 \times 2$ factorial, replicated

four times and laid out on very uniform land. An effective plot size of 324 sq. ft. and very uniform planting material were used. Each plant was staked independently. This seems to indicate that low coefficients of variation are possible where experiments are well designed and laid out and precautions taken to counteract the high inherent variability of the crop.

CONCLUSIONS

1. The yam has a high inherent variation.
2. The variance for tuber weight between the types of planting material (whole tubers, heads, middles and tails) is not homogeneous and thus they cannot be compared for differences using the variance ratio (F).
3. Variance for tuber weight in the types of planting material increases from whole tubers through tails, middles and heads to aerial tubers. Types with the lower variance are more suited for experimental work.
4. The variance for tuber number between planting material taken from different sizes of mother tubers is not homogeneous and the variance ratio (F) does not apply.
5. Coefficients of variation in experiments on yams are not always high if experiments are well designed and the best experimental techniques used.

ACKNOWLEDGEMENTS

This work was carried out as part of the Rockefeller financed Root Crop Research Programme of the Faculty of Agriculture, U. W. I., Trinidad. The authors are indebted to Mrs. P. EDWARDS of the Biometrics Unit and to the technical assistants who assisted in this project.

SUMMARY

There is some evidence in the literature of high variability in yams. Little work has been recorded as to the source of the variability. In this paper yams are shown to have a high inherent variability but it can be controlled with good experimental designs and techniques. The variance in yield was not homogeneous for the different types of planting material and thus an analysis of variance is not valid. Similarly the variance in tuber number for pieces taken from different sizes of mother tubers was not homogeneous. Variance in yield seems to increase from whole tubers through tails, middles and heads to aerial tubers.

RÉSUMÉ

ÉTUDE DE LA VARIABILITÉ CHEZ L'IGNAME (*Dioscorea* spp.)

Il résulte des études disponibles dans la bibliographie que l'igname est caractérisée par une très grande variabilité. Ce travail permet de discuter la variabilité de trois espèces qui ont fait l'objet de nos expérimentations. On présente une approche des relations entre le nombre de tiges, le nombre de tubercules et le poids des tubercules.

REFERENCES

- BARTLETT (M. C.), 1937. — Some examples of statistical methods of research in agriculture and applied biology. *J. Roy Soc. Suppl.*, **4**, 137-183.
- CHAPMAN (T.), 1956. — Some investigations into the factors limiting yields of the White Lisbon Yam (*Dioscorea alata* L.) under Trinidad conditions. *Trop. Agric. Trin.*, **42** (2) 145-51.
- FERGUSON (T. U.), 1969. — Mineral and Calorie content of Yam Tubers. Half Yearly Report 1968/69. Faculty of Agric. U. W. I., Trinidad.
- FERGUSON (T. U.) and HAYNES (P. H.), 1969. — Set Weight X Set Types X Planting Material Trial. Half Yearly Report 1968/69. Faculty of Agric. U. W. I., Trinidad.
- GOODING (E. G. B.) and HOARD (R. M.), 1967. — Experiments on Yams 1966-67. Barbados Sugar Producers Association (Inc.) Crop Diversification Section.
- HAYNES (P. H.), 1967. — The development of a commercial system of yam production in Trinidad. *Tropical Agric. Trin.*, **44** (3) 215-221.
- IRVING (H.), 1956. — Fertilizer experiments with yams in Eastern Nigeria 1947-1951. *Trop. Agric. Trin.*, **33** (1) 67-78.
- KASASIAN (L.) and SEEYAVE (J.), 1967. — Weed control in root crops grown in the West Indies. Proc. Int. Symp. Trop. Root Crops, Trinidad (in press).
- MEIGE (J.), 1957. — The influence of certain characters of seed tubers on the growth and yield of cultivated yams. *J. Agric. trop. Bot. appl.*, **4** (7-8) 315-342.
- SEELYAVE (J.), 1969. — Effect of Weed Competition on yams. Half Yearly Report 1968/69. Faculty of Agriculture, U. W. I., Trinidad.
- SMITH (H. F.), 1938. — An empirical law describing heterogeneity in yields of agricultural crops. *J. Agric. Sci.*, **28**, 1-23.
- STEEL (R. G. D.) and TORRIE (J. H.), 1960. — Principles and procedures of statistics. McGraw Hill Book Company, Inc., New York.

TABLE I

Detail of treatments for the main study

Treatment	Species	Weight of Planting piece ozs.	Type	Weight of Mother Tuber ozs.
1	<i>D. alata</i>	4	Whole Tuber	—
2	<i>D. alata</i>	4	Head	8-16
3	<i>D. alata</i>	4	Tail	8-16
4	<i>D. alata</i>	4	Head	Over 24
5	<i>D. alata</i>	4	Middle	Over 24
6	<i>D. alata</i>	4	Tail	Over 24
7	<i>D. alata</i>	4	Aerial	—
8	<i>D. esculenta</i>	c. a. 1 1/2	Whole Tuber	—
9	<i>D. esculenta</i>	1 1/2-4	Whole Tuber	—
10	<i>D. trifida</i>	4	Whole Tuber	—
11	<i>D. trifida</i>	4	Head	8-16
12	<i>D. trifida</i>	4	Tail	8-16

Note : 1 oz. = 28.35 gms.

TABLE 2 (a)
*Variance, Standard Deviation and Coefficients of Variation
as observed in the preliminary study for tuber number*

Group	Mean Tuber No.	Variance	Coefficient of Variation %
1	4.80	10.3	66.85
2	6.75	5.5	34.74
3	7.23	6.3	55.60
4	9.36	34.7	62.94
5	4.90	16.7	83.11
6	8.00	19.2	54.77
7	7.80	13.2	46.58
8	5.10	7.6	51.05
9	5.80	27.4	90.26
10	5.70	15.1	68.17
Between groups	71.3	360.9	25.65

TABLE 2 (b)
*Variance, Standard Deviation and Coefficients of Variation
observed in the preliminary study for tuber wt. (gms.)*

Group	Mean Tuber Wt.	Variance × 10 ⁴	Coefficient of Variation %
1	1 814	167.99	71.11
2	1 102	55.72	67.70
3	497	2.97	29.13
4	580	13.86	64.14
5	739	21.99	60.51
6	1 223	89.17	77.19
7	668	5.30	33.58
8	564	16.22	71.36
9	977	25.35	51.48
10	647	12.48	54.56
Between Groups	9 324	3 509	58.84

TABLE 3 (a)
*The Effect of Planting Material
on Stem Number, Tuber Number and Yield of Tubers*

Treatments (as in Table 1)	Stem No. per plant	Tuber No. per plant	Yield per plant (kgs)
1	2.32	2.63	1.59
2	2.73	3.18	2.05
3	3.01	3.17	1.79
4	2.43	2.30	1.98
5	2.46	2.47	1.84
6	2.70	2.79	1.93
7	2.79	2.83	1.85
8	1.78	15.75	1.06
9	2.03	22.17	1.67
10	2.09	6.36	0.68
11	1.06	3.89	0.76
12	1.92	4.63	0.70
C. V. % →	18.04	18.48	23.30

TABLE 3 (b)

*Duncan's Multiple Range Test at
5 % level for treatments in Table 3 (a)*

Stem number

All treatments	11	8	12	9	10	1	4	5	6	2	7	3
<i>D. alata</i> treatments	1	4	5	6	2	7	3					

Tuber number

All treatments	4	5	1	6	7	3	2	11	12	10	8	9
<i>D. alata</i> treatments	4	5	1	6	7	3	2					

Tuber weight

All treatments	10	12	11	8	1	9	3	5	7	6	4	2
<i>D. alata</i> treatments	No significant difference											

TABLE 4

*The variance and their significance (5 % level)
as observed by Bartlett's test, and
the coefficients of variation*

(a) Stem Number

Treatment (as in Table 1)	Variance	Coefficient of Variation %
8	0.53	41.2
9	0.76	43.1
4	1.20	45.4
5	1.28	46.0
1	1.41	51.2
6	1.58	46.8
3	1.58	41.8
7	1.59	45.2
11	1.59	119.0
2	1.70	47.8
10	2.32	72.9
12	4.61	111.8

TABLE 4
(b) Tuber Number

Treatment (as in Table 1)	Weight of Mother Tuber ozs.	Variance	Coefficient of Variation %
5	> 24	2.13	59.1
4	> 24	2.15	64.7
7	—	2.42	55.0
6	> 24	3.01	62.2
1	—	3.05	66.4
2	8-16	3.37	57.8
3	8-16	4.31	65.5
10	—	17.65	66.0
11	8-16	23.65	124.9
12	8-16	25.26	108.6
8	—	50.91	55.3
9	—	56.54	33.9

TABLE 4
(c) Tuber Weight (gms.)

Treatment (as in Table 1)	Type	Variance $\times 10^4$	Coefficient of Variation %
10	Whole Tuber	32.00	83.7
8	Whole Tuber	34.72	55.6
9	Whole Tuber	56.36	44.9
1	Whole Tuber	70.07	52.6
12	Tail	81.58	128.1
6	Tail	86.31	48.1
3	Tail	118.73	60.7
5	Middle	123.39	66.3
11	Head	152.84	162.6
2	Head	163.89	62.4
4	Head	169.29	65.8
7	Aerial	186.75	73.9