REPRINTED FROM

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE.

Vol. II, Part VI, December, 1932.

STATISTICAL NOTES FOR AGRICULTURAL WORKERS

NO. 5.—A NOTE ON THE VARIATION OF PERCENTAGE INFECTION OF WILT DISEASE IN COTTON

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(Received for publication on the 18th August 1932)

Mr. G. S. Kulkarni, Special Cotton Mycologist, Dharwar, observed that certain selected strains of cotton, resistant to the wilt disease under field conditions succumb to the same disease under controlled conditions of the laboratory in pot-culture experiments. He is of opinion that resistance to wilt disease under field conditions is chiefly due to the want of favourable conditions for the causal organism of the disease to be pathogenic. To test this assumption a large number of plants of the selected strain "Jayawant" was sown in six replications in three batches in June, July and August, 1931, respectively. As temperature conditions in June and July were believed to be more favourable for wilt production, it was expected that the percentage infection would be greater for the plants sown in June than for those sown in the later months.

The data sent by Mr. Kulkarni covered unequal periods of time for the different replications. Dr. B. B. Mundkar, who was associated with Mr. Kulkarni in this work, has, however, very kindly placed the weekly observations at our disposal. This makes it possible to compare the mortality figures covering 24 weeks after the date of sowing in each case. The relevant data will be found in Table I.

TABLE I

Plot No.	Sowing time	No. of plants sown	No. of wilted plants	Percentage* infection
1	June	1,159	106	9·15
	July	1,097	126	11·49
	August	1,139	129	11·33
2	June	1,125	214	19·02
	July	1,107	185	16·71
	August	1,180	183	12·45

*The percentages were calculated in our Laboratory.

TABLE I—*contd.*

Plot No.	Sowing time	No. of plants sown	No. of wilted plants	Percentage* infection
3	June	1,130	223	19·74
	July	1,100	168	15·27
	August	1,177	109	9·26
4	June	1,117	248	22·22
	July	1,068	115	10·77
	August	1,080	195	18·06
5	June	1,159	316	27·26
	July	1,084	215	19·83
	August	1,107	185	16·80
6	June	1,100	253	23·18
	July	1,042	202	19·38
	August	1,129	173	15·32

From the statistical standpoint, on the available data, it is possible to test whether there are significant differences in percentage infection between plants sown in different months. But, on the given data, it is not possible either to confirm or to reject the hypothesis that the growth of wilt disease in resistant strains in the laboratory is due to the presence of favourable conditions.

The variation in percentage infection may be classified under thre heads. Variations due to :

(1) difference in the date of sowing.
(2) differences in the soil-character of the six replications.
(3) Random fluctuations.

The analysis of variance into these three heads is shown in Table II below.

TABLE II

Variance due to	Degrees of freedom	Sum of squares	Mean variance	S. D.
Date of sowing . .	2	124·1949	62·0975	7·88
Soil-differences . .	5	205·4791	41·0958	6·41
Residual . . .	10	112·7506	11·2751	3·35
Soil-differences and residual	15	318·2297	21·2153	4·61
	17	442·4246	26·0249	5·10

$$\text{“}Z\text{”} = \tfrac{1}{2}\log_e \frac{62{\cdot}0975}{11{\cdot}2751} = 0{\cdot}8309$$

5 per cent. point of “Z” (corresponding to $n_1=2$ and $n_2=10$)=·7058.

Since the value of Z is above the 5 per cent. point, the association is real, *i.e.*, the percentage of infection varies significantly with the month of sowing.

The analysis may now be given in detail.

TABLE III

Date of sowing	Mean percentage of infection	Diff. from August	Diff. from July
June	20·10	+6·23	+4·53
July	15·57	+1·70	..
August	13·87	—	—1·70

Standard error on mean difference=1·94
Critical difference for significance—
(5 per cent. level)=4·32, (1 per cent. level)=6·15

* Another salient point that comes out at once from the study of the analysis of variance given in Table II is the marked soil-heterogeneity of the experimental plot used in this experiment. Elimination of soil heterogeneity by the above method reduced the residual variance from a value 21·2153 to value 11·2751.

We therefore conclude the difference in percentage infection between—

(1) June and August is definitely significant.

(2) June and July is on the verge of significance.

(3) June and August is practically insignificant.

The percentage of infection in the different months may also be compared directly in pairs. For this purpose the method originally suggested by "Student" in Biometrika, Volume VI, page 19, may be used with advantage.

TABLE IV.

(I) June and August.

Name of replication	Percentage, June	Infection, August	Difference
1	9·15	11·33	—2·18
2	19·02	12·45	6·57
3	19·74	9·26	10·48
4	22·22	18·06	4·16
5	27·26	16·80	10·46
6	23·18	15·32	7·86
Mean=	20·10	13·87	6·23

Mean difference=6·23

Standard deviation of the differences=4·35

$$\text{"}Z\text{"} = \frac{\text{Mean difference}}{\text{Standard deviation}}$$

$$= \frac{6{\cdot}23}{4{\cdot}35} = 1{\cdot}43 \text{ approximately}$$

Using Biometrika Table XXV (page 36)*, we find that for $n=6$, the probability that the mean difference will not exceed (in algebraic sense) zero by more than 1·43 times the standard deviations of the sample is "P"=·9879, *i.e.*, the probability of the difference being a real one exceeds 98 per cent. The difference may, therefore, be considered definitely significant.

* Fisher's t-table (Table IV) which is based on Student's Table may also be used.

TABLE V.

(2) June and July.

Name of replication	Percentage, June	Infection, July	Difference
1	9·15	11·49	—2·33
2	19·02	16·71	2·31
3	19·74	15·71	4·47
4	22·22	10·77	11·45
5	27·26	19·83	7·43
6	23·18	19·38	3·80
Mean=	20·10	15·57	4·53

Mean difference=4·53
Standard deviation of the differences=4·26

"Z"$=\frac{4·53}{4·26}=1·06$, $P=0·9617$

That is, the probability that the mean difference will not exceed zero by more than 1·06 times the standard deviation of the sample is "P"-0·9617. Thus the difference is on the verge of being considered significant.

TABLE VI.

(3) July and August.

Name of replication	Percentage, July	Infection, August	Difference
1	11·49	11·33	0·15
2	16·71	12·45	4·26
3	15·27	9·26	6·01
4	10·77	18·06	—7·29
5	19·83	16·80	3·03
6	19·38	15·32	4·06
Mean=	15·57	13·87	1·70

Mean difference=1·70
Standard deviation of the differences=4·39

"Z"$=\frac{1·70}{4·39}=0·39$

"P"$=0·7879$

That is, the probability that the mean difference will not exceed zero by more than ·39 times the standard deviation of the sample, is "P"=0·7879. As the odds are roughly 4 to 1, the difference cannot be considered significant.

The direct comparison thus leads to the same results as those given by the analysis of variance, namely, the percentage infection of plants sown in June is significantly greater than the percentage infection of plants sown in July and August respectively, while the percentage infections of plants sown in July and August do not appear to be significantly different.

The above note was prepared with the help of a grant from the Imperial Council of Agricultural Research.