THE RELATION OF SOME PLANT CHARACTERS TO YIELD IN CUMBU—*PENNISETUM TYPHOIDES* (Burm.) Stapf and Hubbard—THE PEARL MILLET

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The present study deals with the relationships that subsist between grain yield and some other metrical characters of the Pearl Millet (*Cumbu*, Tamil; *Sajja*, Telugu; and *Bajri*, N. India).

The following six rainfed varieties representative of some distinct types in the Pearl Millet were chosen for study in 1932. The measurements were repeated in 1933.

Selection No.	Population. 1932	Population. 1933
P. T. 17—G.	130	130
P. T. 17—P.	120	85
P. T. 72	130	130
P. T. 248	110	130
P. T. 331	130	130
M. S. 1354	110	125

In Table I are presented the correlation co-efficients between (a) the total grain yield of a plant and (1) height of plant, (2) number of nodes on the main axis, and (3) total number of earheads, and (b) the correlations between the total number of earheads and the average yield per earhead. These are given for both the years.

In the second year of this work, the correlations between the main earhead characters were also studied. Table II presents the correlations between (1) the yield of the main earhead and (2) surface area of the earhead, (3) diameter of the peduncle of the main axis, (4) height of the main axis, (5) length of the earhead, (6) diameter of the earhead, (7) length of the peduncle of the main axis, (8) total number of earheads, and (9) average yield per earhead. The suffix of r used in presenting the partial correlations is as numbered in the list enumerated above.

In order that the significance of the r-values may be readily judged, the correlation co-efficients for the '01 level of significance are entered throughout by finding $\frac{t}{\sqrt{n-2+t^2}}$ where n is the number of observations and t (Fisher's t) corresponding to P = ·01 is obtained from Table XXXV of G. W. Snedecor's 'Analysis of Variance' (1934).

Tests were made to see whether the same degree of correlation exists between the variates (a) in the same variety between two years, (b) between all the varieties in each year, and (c) between all the varieties in both the years. These tests are presented in Table III. z is the hyperbolically transformed r and $\sigma_{z \sim z'}$ the standard error of $z \sim z'$ (L. H. C. Tippett, 1931, the Methods of Statistics, p. 140). From columns 2 to 7 it is evident that the fluctuations of r between 2 years in the same variety are in most cases within the limits of errors of random sampling. X_1^2 and X_2^2 relate to the fluctuations (Tippett. p. 142) of r between all the varieties in 1932 and 1933 respectively, and X^2 relates to all the varieties in both the years. When P for X^2 is above ·05 the corresponding mean value of r is entered by transforming $\bar{z}$ to $\bar{r}$; likewise for X_1^2 and X_2^2.

Relation between the Total Grain Yield of a Plant and Some Other Characters. *Total grain yield and height.* The height of a plant is taken as the height of the main axis measured from the soil level to the tip of the earhead. The variations of r between the varieties in each year are beyond the limits of errors of random sampling. (Table III). In no case is the r value high, though significant. The mere height of a plant gives little indication of its capacity to yield well,

Total grain yield and the number of nodes. The number of nodes (and these mean leaves) is reckoned on the main axis. The fluctuations of r are not significant (Table III). z = ·20 is significant, the standard error being ·03. However, this value is too low to consider the number of nodes as of importance in estimating the total grain yield.

Total grain yield and the total number of earheads, In 1932 the r-values fluctuate widely but not in 1933 (Table III). The correlation coefficients are fairly high throughout. A plant with a large number of earheads is to be preferred though the total number of earheads is negatively correlated with the average yield per earhead (Table I.)

An estimate of the total grain yield can be made when in addition to the total number of earheads being known an estimate of the average yield per earhead is possible. It was therefore thought fit to explore the possibility of any single earhead giving an indication of the average yield per earhead, and the main earhead, which is a convenient fixture was chosen for this study. It was found that the yield of this main earhead is correlated with the average yield per earhead (Table II). For this reason attention was directed to investigate the factors that contributed to the yield of the main earhead.

Relation between the yield of the main earhead and some other characters. *Main earhead yield and the total number of earheads.* The main earhead yield is independent of the total number of earheads produced on a plant. The corresponding correlations are (except in one case) below the level of significance (Table II).

Main earhead yield and its surface area. The inflorescene of this millet is a terminal compound spike. The grains are borne on rachillae disposed round an unbranched rachis in a seriate arrangement. A ripe earhead presents the appearance of grains packed on a surface almost cylindrical about the rachis. The surface area of the earhead can be taken approximately as being proportional to dl, d being the diameter and l the length of the earhead. It is seen from Table III that all the correlation coefficients can be combined and the improved estimate of r is ·67. The partial correlations obtained by eliminating the effect of the thickness of the peduncle and the height of the main axis, the two factors which bear some relation to yield, are considerable (Table IV).

Main earhead yield and the length and the diameter of the earhead. The yield is correlatad with the length and the diameter of the earhead, these being the dimensions determining the surface area. It is found from Table III that in both cases the several values of r can be combined, $\bar{r}_{15} = \cdot 53$ and $\bar{r}_{16} = \cdot 52$. These two factors supply more information when combined to derive the surface area, than singly.

Main earhead yield and the length and the diameter of the peduncle. The length of the peduncle of the main axis is the distance between the topmost node and the base of the earhead. The diameter of the peduncle was measured with Vernier callipers at a standard distance of 5 cm. below the base of the spike. Table III shows that in both cases the r's can be combined. $\bar{r}_{17} = \cdot 20$ is just above the level of significance but not high enough to consider the length of the peduncle as an index to yield. $\bar{r}_{13} = \cdot 64$ showing that a thick peduncle is a mark of high yield. The partical correlation obtained by eliminating the effect of the surface area are smaller than those obtained by eliminating the effect of height (Table IV). The high correlation between the peduncle thickness and yield is due to the close relationship subsisting between the peduncle thickness and the surface area which has a direct relation with yield.

Main earhead yield and the height of the main axis. The correlations between the main earhead yield and the height of the shoot bearing this earhead fluctuate from variety to variety (Table III). The correlations are significant but generally not high enough to rely on this factor by itself as a guide to yield.

Multiple Correlation Coefficients. The multiple correlation coefficients between the yield of the main earhead and the surface area of the earhead, the thickness of peduncle and the height of the main axis (the three factors that were worth pursueing) are given in Table V. The table commences with r_{12} because of the direct relation that surface area has with yield. The R-values for the ·01 level of significance are entered by taking $\sqrt{\dfrac{me^{2z}}{N-m-1+me^{2z}}}$ where m is the number of independent variates, N the size of the sample, and e^{2z} corresponding to $n_1=m$ and $n_2=N-m-1$ is obtained from Table XXXV of Snedecor's 'Analysis of Variance.' Throughout, $R_{1\cdot234}$ is significantly above r_{12}. The tests of significance presented in Table VI were carried out by considering P corresponding to

$$z=\tfrac{1}{2}\log_e \frac{(R^2_{1\cdot234}-r^2_{1\cdot2})\,(N-4)}{2\,(1-R^2_{1\cdot234})}$$

for degrees of freedom $n_1=2$ and $n_2=N-4$ (Tippett 1931. p. 208). It is concluded that the additional factors namely the thickness of peduncle and the height of the main axis help to predict the grain yield of the main earhead with a greater precision than is possible with a knowledge of the surface area only.

Summary. The correlations between the total grain yield per plant and the height of the main axis, the number of nodes in it, and the total number of earheads were determined in six rainfed varieties of the Pearl Millet in two years. The number of heads is correlated with yield. The other factors are but slightly correlated. The average yield per head is correlated to the yield of the main earhead. The yield of the main earhead is correlated with the length, the diameter and the surface area of the earhead, the thickness of peduncle, and the height of the main axis, while the length of peduncle bears no correlation to yield.

Partial and multiple correlations were also calculated. The yield of the main earhead can be predicted with a fair amount of certainty when the surface area of that earhead, the thickness of its peduncle, and the height of its axis, are known.

Table I.

Total correlation coefficients.

Correlates	P.T. 17/G		P.T. 17/P		P. T. 72		P. T. 248		P. T. 331		M.S. 1354	
	1932	1933	1932	1933	1932	1933	1932	1933	1932	1933	1932	1933
Total grain yield and height	·30	·08	·30	·27	.53	·36	·27	·29	·59	·41	·41	·09
,, ,, number of nodes	·19	·11	·20	·07	·14	·36	08	·16	·44	·14	·20	·13
,, ,, number of ear-heads	·69	·69	·65	·71	·46	·73	·51	·80	·59	·72	·83	·70
Number of ear-heads and average yield per ear-head	–·60	–·59	–·56	–·62	–·59	–·44	–·63	–·46	–·27	–·37	–·35	–·55
Level of significance (P=·01)	·23	·23	·23	·28	·23	·23	·25	·23	·23	·23	·25	·23

Table III.

Combination of the correlation co-efficients.

Correlates.	$\frac{z \sim z'}{\sigma_{z \sim z'}}$ (z for 1932, z′ for 1933)						All the varieties in 1932		All the varieties in 1933		All the varieties in 1932 & 1933	
	P. T. 17–G.	P. T. 17–P.	P. T. 72.	P. T. 248.	P. T. 331.	M. S. 1354.	X_1^2	$\bar{r}$	X_2^2	$\bar{r}$	X^2	$\bar{r}$
1	2	3	4	5	6	7	8	9	10	11	12	13
Total grain yield and height	1·75	·21	1·35	·15	1·43	2·42	17·04	...	13·82	...	42·39	...
" number of nodes	0·64	·90	1·75	·61	2·39	0·53	11·05	·22	7·20	·17	19·14	·20
" number of earheads	...	·76	2·15	4·12	1·04	0·98	34·51	...	5·10	·73	51·14	...
Number of earheads and average yield per earhead ...	0·08	·69	1·20	1·83	0·80	1·51	21·97	...	9·78	-·59	31·75	...
Main earhead yield and surface area of earhead ...	...	...	...	...	...	...	...	...	6·24	·67	...	...
" diameter of peduncle	...	...	...	...	...	...	...	...	2·31	·64	...	...
" height of main axis	...	...	...	...	...	...	...	...	27·98	...	...	...
" length of earhead	...	...	...	...	...	...	...	...	7·44	·53	...	...
" diameter of earhead	...	...	...	...	...	...	...	...	3·86	·52	...	...
" length of peduncle	...	...	...	...	...	...	...	...	9 81	·20	...	...
" number of earheads	...	...	...	...	...	...	...	...	6·50	·11	...	...
" average yield per earhead ...	...	...	...	...	...	...	...	...	22·32	...	...	...
							P = ·05 X_1^2 = 11·07		P = ·05 X_2^2 = 11·07		P = ·05 X^2 = 19 68	

Table II.

Total correlation co-efficients.

Main earhead yield and other factors.

Correlates.	P. T. 17-G	P. T. 17-P	P. T. 72	P. T. 248	P. T. 331	M. S. 1354
Main earhead yield & surface area of earhead.	·66	·69	·74	·69	·57	·65
„ „ diameter of peduncle.	·69	·58	·65	·62	·63	·61
„ „ height of main axis.	·37	·48	·55	·61	·76	·46
„ „ length of earhead.	·51	·57	·44	·60	·45	·62
„ „ diameter of earhead.	·48	·56	·59	·44	·53	·55
„ „ length of peduncle.	·19	·05	·12	·10	·36	·31
„ „ number of earheads.	– ·10	– ·17	– ·07	– ·06	– ·01	– ·29
„ „ average yield per earhead.	·67	·67	·67	·72	·84	·58
Level of significance (P = ·01).	·23	·28	·23	23	·23	·23

Table IV.

Partial correlation coefficients.

Main ear-head yield and other factors.

r	P. T. 17/G.	P. T. 17/P.	P. T. 72	P. T. 248	P. T. 331	M. S. 1354
r_{12}	·66	·69	·74	·69	·57	·65
r_{13}	·69	·58	·65	·62	·63	·61
r_{14}	·37	·48	·55	·61	·76	·46
Level of significance (P = ·01)	·23	·28	·23	·23	·23	·23
$r_{12\cdot3}$	·39	·54	·56	·49	·27	·42
$r_{12\cdot4}$	·61	·65	·65	·59	·37	·57
$r_{13\cdot2}$	·59	·31	·36	·31	·41	·34
$r_{13\cdot4}$	·66	·43	·58	·54	·54	·56
$r_{14\cdot2}$	·20	·39	·40	·45	·68	·29
$r_{14\cdot3}$	·24	·25	·45	·53	·71	·37
Level of significance (P = 01)	·23	·28	·23	·23	·23	·23
$r_{12\cdot34}$	·36	·56	·49	·40	·09	·35
$r_{13\cdot24}$	·59	·17	·35	·31	·42	·33
$r_{14\cdot23}$	·17	·29	·39	·45	·68	·29
Level of significance (P = ·01)	·23	·28	·23	·23	·23	·23

Table V.

Multiple correlation coefficients.

Main earhead yield and other factors.

R	P. T. 17-G	P. T. 17-P	P. T. 72	P. T. 248	P. T. 331	M. S. 1354
r_{12}	·66	·69	·74	·69	·57	·65
$R_{1\cdot23}$	·79	·73	·78	·73	·67	·70
$R_{1\cdot24}$	67	·75	·78	·77	·80	·69
$R_{1\cdot34}$	·71	·61	·73	·74	·84	·67
Level of significance (P = ·01)	·27	·33	·27	·28	·28	·27
$R_{1\cdot234}$	·80	·75	·79	·79	·84	·73
Level of significance (P = ·01)	·29	·36	·29	·29	·29	·30

Table VI.

Tests of significance of the difference between $R_{1\cdot234}$ and r_{12}.

Selection.	$z_{1\cdot234-12}$	Degrees of freedom.		P
		n_1	n_2	
P. T. 17-G	1·68	2	126	< 0·01
P. T. 17-P	1·08	2	126	< 0·01
P. T. 72	1·30	2	126	< 0·01
P. T. 248	1·60	2	81	< 0·01
P. T. 331	1·63	2	126	< 0·01
M. S. 1354	1·31	2	121	< 0·01

THE TOBACCO TRADE OF MADRAS,—PART I.

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Introduction. In the solution of marketing problems in the different crops, the study of the existing trade with special reference to general world position occupies an important part. With the exception of United States of America, India is the largest producer of tobacco (1000 million lb.) in the world. In the production of tobacco of commerce, Madras occupies the premier position among the provinces. In response to the preference for Empire tobacco accorded in 1919 and subsequently in 1925 there has been a corresponding increase in acreage and production, though not in the quality of the product, the character for which this commodity is most valued; consequently India has not derived as much benefit out of the preference as was expected. As the balance of trade in tobacco is unfavourable consideration of the external trade in this commodity with other countries requires earlier attention than that of the internal trade.

The imports of the following countries given below indicate the magnitude of the demand for tobacco. Quinquennial averages for such purposes are preferred to a single annual import figures from the consideration of peculiarities of the trade in this commodity.

Table I. *Imports of Principal Countries in million lb.*

Importing Countries.	Average of 1925—'29.	1930.
Germany	218	235
United Kingdom	203	223
China	105	124
France	92	155
Netherlands	70	70
Spain	54	57
Belgium	45	49
Czecho Slovakia	39	23
Poland	34	42
Austria	31	22
Argentina	24	23
Australia	22	20