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Von Oppen,M.K.

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MEASUREMENTS OF PIGEONPEA SEED CHARACTERISTICS

Some preliminary observations

By

M. von Oppen

General Problem:

It is a well known fact, that consumers are preferring some types of Pigeonpeas over others, and market prices are reflecting this fact to some extent. However, very little is known about how to quantitatively distinguish between different qualities of Pigeonpeas.

A system of standardized tests is required, which allows to measure exactly the amount of certain relevant characteristics of a given sample of Pigeonpeas. In this context of consumer preferences only those characteristics can be called relevant, which are perceptible by the consumer/trader, either by direct observation of the qualities or by indirect inference drawn from the observation of related evident characteristics.

It is very difficult to determine what traders or consumers might have in mind, when they decide about their preferences for some type of grain over another, especially since probably every one of them has his individual way of making such decisions. These might be organoleptically observable qualities such as colour or colour mix and lustre sizes and shapes of the seeds from which the dal miller may draw conclusions about the dal yields he can expect. Or it might be seed density which is probably tested by the buyer who takes a sample into his hand and in several typical

movements of throwing and catching " weighs " the grains. By biting or chewing the seed, buyers sometimes may test hardness and/or flavour of the grain and infer from these to other characteristics. The house wife may prefer a short cooking time of the dal, good swelling capacity and an agreeable colour and a good flavour of the dal.

Data Analysed:

In an effort to learn more about the measurement of these characteristics and their relationships among each other, a set of eight presumably relevant characteristics[1] in Pigeonpea seeds was measured for 36 samples of different types of grain provided by the Pigeonpea breeders.[2]

It may be assumed that traders/consumers are able to observe although, they usually don't measure some of these characteristics directly and that they infer about the others indirectly from those they observe (Table 1, Col. 4). The relationships on the basis of which presumably inferences are drawn can be described verbally (Table 1, Col. 5). To test whether these assumptions are true, the postulated relationships are formulated in mathematical terms (Table 1, Col. 6). Table 2 gives the correlation matrix of the variables included. The results of the relationships tested

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1) See Table 1, Col. 1,2 and 3
2) A list of sample numbers included in the analysis is given in the Appendix.

are given in the form of the regression equations, corresponding t-values and coefficients of multiple correlation (see Table 3).

TABLE 1:

MEASUREMENTS AND RELATIONSHIPS OF SELECTED SEED CHARACTERISTICS OF PIGEAN PEAS

SYMBOL	CHARACTERISTIC	LABORATORY MEASUREMENT	TRADERS', MILLERS' AND/OR CONSUMERS MEASUREMENTS OR OBSERVATIONS	RELATIONSHIPS ASSUMED	RELATIONSHIPS TESTED
1	2	3	4	5	6
X_1	100-seed--weight	Grams	Direct observation of seed size		
X_2	Seed density	Volume of 10 grams of dry seed in 20 ml. of water	Indirect observation by "weighing" in the hand		
X_3	Water up take after 24 hours of soaking	(a) Weight in grams (b) Volume in ml. (c) Percentage of unsoaked grains	Direct observation of swelling when preparing dal	- Water uptake measured in grams is directly proportional to water uptake measured in ml. - The higher the percentage of unsoaked grains, the lower the water uptake.	$X_{3a} = f(X_{3b})$ $X_{3c} = f(X_{3a})$
X_4	Colour mix	Percentage of number of grains of six standard colours 1)	Direct observation of different colours in the sample.		

1) X_{4A} = Green
X_{4B} = White
X_{4C} = Light red
X_{4D} = Dark red
X_{4E} = Black, purple and speckled
X_{4F} = Unidentifyable, damaged grains.

(Table 1 Contd..)

(Table 1 Contd...)

1	2	3	4	5	6
Y_1	Dal yield	Percent of weight recovered	Observation and measurement when preparing dal	High dal yield if: - large seed size - white seed colour - high water uptake - high seed density	$Y_1 = f[X_1, (X_1)^2]$ $Y_1 = f(X_4)$ $Y_1 = f[X_3, (X_3)^2]$ $Y_1 = f[X_1, X_3, X_4]$
Y_2	Cooking time	Minutes till dal is soft	Observation of deviation from normal cooking time	Short cooking time if: - small seed size - low seed density - high water uptake	$Y_2 = f[X_1, (X_1)^2]$ $Y_2 = f[X_3, (X_3)^2]$ $Y_2 = f[X_1, X_3, X_4]$
Y_3	Increase in volume after cooking	Milli letres	Observation of "swelling" during cooking	Good "swelling" if: - high water uptake - high seed density - large seed size	$X_{3a} = f(Y_3, Y_4)$
Y_4	Increase in weight after cooking	Grams			

TABLE 2: CORRELATION COEFFICIENTS OF CHARACTERISTICS

	Y_1	Y_2	Y_3	Y_4		X_1	X_2	X_{3a}	X_{3b}	X_{3c}	X_{4A}	X_{4B}	X_{4C}	X_{4D}	X_{4E}	X_{4F}
Y_1	1															
Y_2	.315	1														
Y_3	.128	.439	1													
Y_4	-.034	.484	.359	1												
X_1	-.227	-.507	-.629	-.363		1										
X_2	-.095	.039	.272	.068		-.288	1									
X_{3a}	.244	.315	.210	-.166		-.146	.303	1								
X_{3b}	.219	-.066	.205	-.181		-.135	.139	.965	1							
X_{3c}	-.237	-.067	-.316	.091		.287	-.193	-.923	-.897	1						
X_{4A}	-.195	-.262	-.202	.100		.349	-.153	.122	.121	-.082	1					
X_{4B}	-.092	-.293	-.319	-.023		.501	-.067	.240	.208	-.133	.764	1				
X_{4C}	-.157	-.123	-.304	-.047		.193	-.409	-.369	-.313	.296	-.169	-.304	1			
X_{4D}	.132	.288	.504	-.084		-.552	.452	.361	.363	-.333	-.447	-.470	-.536	1		
X_{4E}	.198	-.001	-.075	.238		.101	-.134	-.460	-.515	.385	.038	-.016	-.143	-.388	1	
X_{4F}	-.237	.475	.535	.091		-.629	.395	.354	.384	-.378	-.295	-.322	-.351	.624	-.303	1

TABLE 3: LIST OF REGRESSIONS FITTED

(t-values in brackets and coefficients of multiple correlation, R^2)

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(1) $$X_{3a} = \underset{(-.136)}{-.056} + \underset{(21.6)}{.973}\, X_{3b} \qquad R^2=.93$$

(2) $$X_{3c} = \underset{(16.4)}{84.2} - \underset{(13.9)}{7.87}\, X_{3a} \qquad R^2=.85$$

(3) $$Y_1 = \underset{(6.4)}{86.1} - \underset{(1.024)}{1.54}\, X_1 + \underset{(.78)}{.059}\, (X_1)^2 \qquad R^2=.07$$

(4) $$Y_1 = \underset{(.041)}{75.6} - \underset{(1.08)}{221.9}\, X_{4A} + \underset{(.88)}{4.88}\, X_{4B} + \underset{(.343)}{1.34}\, X_{4D}$$

$$+ \underset{(1.407)}{7.45}\, X_{4E} + \underset{(1.0)}{29.4}\, X_{4F} \qquad R^2=.14$$

(5) $$Y_1 = \underset{(4.7)}{73.4} + \underset{(.361)}{.633}\, X_{3a} - \underset{(.065)}{.0078}\, (X_{3a})^2 \qquad R^2=.06$$

(6) $$Y_1 = \underset{(.58)}{73.9} - \underset{(.680)}{.287}\, X_1 + \underset{(1.864)}{.865}\, X_{3a} - \underset{(1.175)}{237.0}\, X_{4A}$$

$$+ \underset{(.364)}{2.22}\, X_{4B} - \underset{(.342)}{1.37}\, X_{4D} + \underset{(1.82)}{9.82}\, X_{4E} + \underset{(.248)}{8.08}\, X_{4F} \qquad R^2=.24$$

(7) $$Y_2 = \underset{(3.2)}{83.3} - \underset{(1.96)}{5.73}\, X_1 + \underset{(1.31)}{.193}\, (X_1)^2 \qquad R^2=.29$$

(8) $$Y_2 = \underset{(.96)}{33.2} + \underset{(1.31)}{5.07}\, X_{3a} - \underset{(1.41)}{.371}\, (X_{3a})^2 \qquad R^2=.06$$

(Contd....)

TABLE 3:(Contd...)

(9) $$Y_2 = \underset{(.251)}{65.52} - \underset{(1.6)}{1.39}\, X_1 - \underset{(1.13)}{1.08}\, X_{3a} - \underset{(.503)}{208.5}\, X_{4A}$$

$$+ \underset{(.487)}{6.09}\, X_{4B} - \underset{(.142)}{1.17}\, X_{4D} + \underset{(.202)}{2.24}\, X_{4E} + \underset{(1.67)}{111.4}\, X_{4F} \qquad R^2 = .35$$

(10) $$X_{3a} = \underset{(-3.19)}{-9.75} - \underset{(1.578)}{.542}\, Y_3 + \underset{(1.76)}{4.56}\, Y_4 \qquad R^2 = .11$$

DISCUSSION OF THE RESULTS AND IMPLICATIONS

The first equation may indicate a consistant measurement error, i.e., in measuring the water uptake in terms of millilitres (X_{3b}) an upward reading mistake may have been made in comparison to weighing the water uptake in grams. Assuming, however, that the weight measures and the volume measures both are correct, this finding implies that the water which was absorbed by the seed and thus was measured in the weight increase caused a more than proportionate increase in seed volume. If this is true, then the difference between water uptake in weight and in volume could give valuable clues as to the nature and structure of the seed body[1].

Equation (2) Confirms the hypothesis that the higher the percentage number of hard grains in the sample, the lower the water uptake is. In the process of preparing dal, hard grains may cause problems, because of difficulties in the removal of their seed coat. This can be tested by postulating:

$$Y_1 = f[\ X_{3c},\ (X_{3c})^2\ ]$$

Also, another measurement of water uptake capacity of seeds (X_{3d}) will be taken, where the occurance of hard seeds is excluded by slightly damaging the seed coats before soaking[2]. If this measurement shows sufficient variability a regression with it and other variables could be run to explain cooking time:

$$Y_2 = f\ (\ X_{3d},\ X_2\ )$$

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1) It could be observed, that this difference varies considerably from one sample to another. However, more precise measurement techniques would be required to give sufficient confidence in such observations.

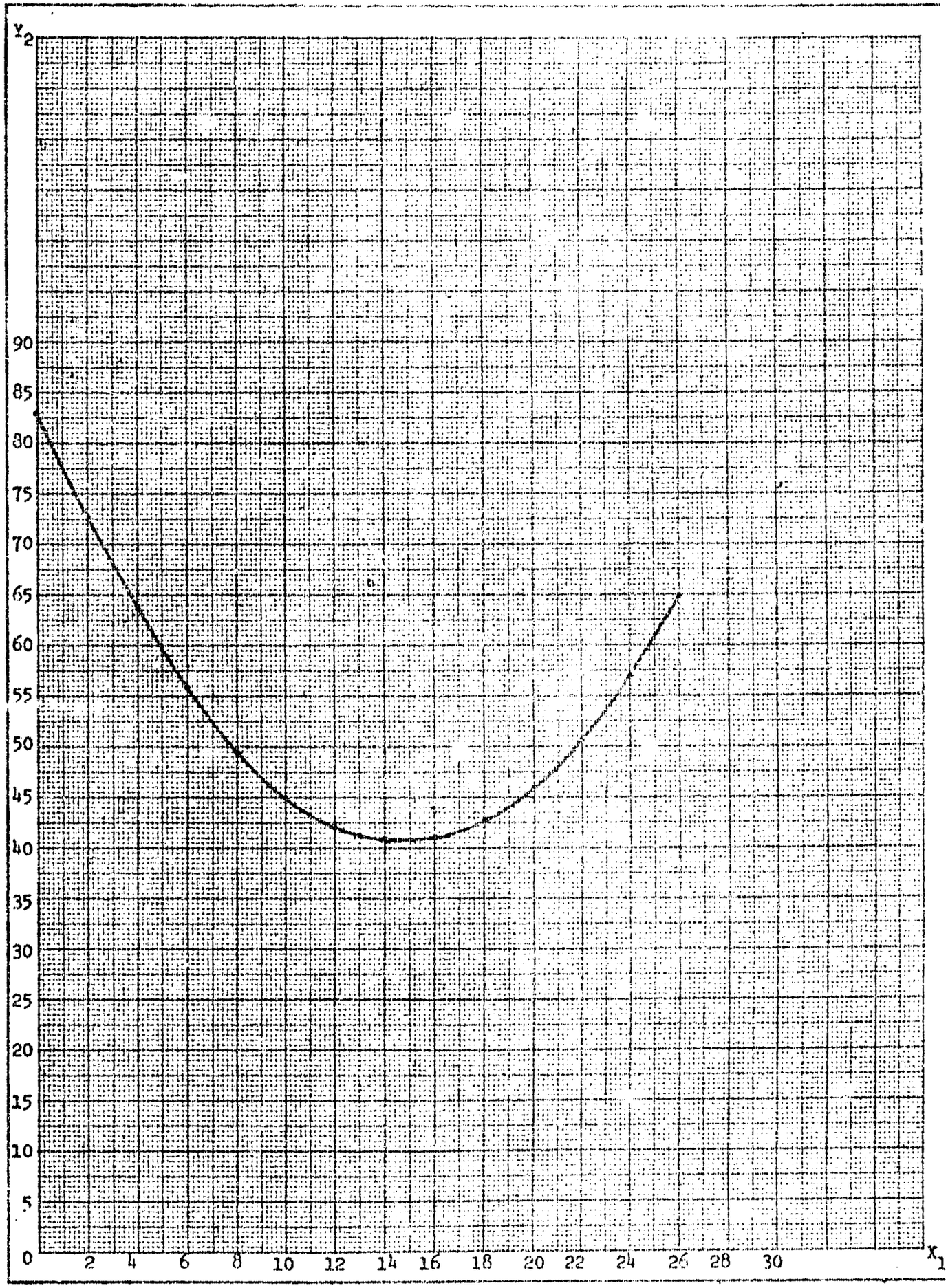
2) Hard seeds can be shown to generally have perfect swelling as soon as the impermeable seed coat is made permeable by pricking.

Equations (3) through (6) try to explain the dal yield (Y_1). The results show that in the form of a quadratic equation neither 100-seed-weight (X_1) nor water uptake (X_{3a}) can explain dal yield. Also the seed colourmix in the specified linear form has very little meaning for explaining as well as predicting dal yield. If taken together in equation (6) we find that 100-seed-weight, water uptake and colour jointly explain 24% of the variation in dal yields. Water uptake and the percentage number of black, purple and speckled colours are positively related with dal yield with a statistical significance of 10% probability. In total none of these equations gives a satisfactory explanation for variations in dal yield. Equations (7) through (9) were set up to explain variations in cooking time. A relatively strong explanation (29%) is offered by equation (7) which relates cooking time and 100-seed-weight in the form as depicted in Figure 1:

From smaller to larger seed sizes cooking time decreases upto a 100-seed-weight of 14.8 grams. For seed sizes larger than that, cooking time increases.

Equations (8) and (9) are lacking explanatory and predictive power.

In equation (10) the variation in water uptake is explained to 11% by the two variables which are measured after cooking, at 10% pro-



100- Seed-Weight (Grams)

bability levels, i.e., the water uptake capacity is negatively related to the increase in volume after cooking, but positively related to the increase in weight after cooking.

The opposing behaviour of these two variables with respect to water uptake of the whole seed suggests that two different mechanisms in the grain must be independently responsible, one for the expansion of the volume of cooked product, the other for the water uptake of the cooked product. This should be further tested by relating Y_3 and Y_4 independently to X_1, X_2, X_3 and X_4.

CONCLUSION

This is the very first approach of linking some cooking characteristics, to other evident characters.

Dal yield, cooking time and increase in volume and weight were related to characters measured with whole seeds such as 100-seed-weight, water uptake, percentage of hard seeds and colour mix. In the correlation matrix, the highest coefficient found between any of the cooking characters and any of the more evident characters was $R(Y_3/X_1) = -.63$. By specifying certain fundamental forms of related characters however, it was possible e.g., to explain 29% of the variation in cooking time by a linear and a quadratic form of 100-seed-weight (Fig. 1). This example shows that if speci-

fying relationships correctly, one may discover functional relationships which do have explanatory power and which are statistically significant. These calculations will be repeated as soon as results of the remaining cooking tests on Pigeonpeas at the College of Home Science are available to us, thus increasing the sample size from presently 35 to about 60. In the meanwhile comments and suggestions are invited, on how to improve the specification of functional relationships, so as to explain cooking qualities by evident quality characters.

APPENDIX

ICRISAT Serial Numbers of 36 Seed Samples included in the Analysis

No.	ICRISAT Sl. No.	No.	ICRISAT Sl. No.
1	7119	21	7193
2	7191	22	7192
3	6965	23	7203
4	7118	24	7181
5	2624	25	4741
6	7190	26	3773
7	7182	27	4780
8	1	28	7105
9	7120	29	4726
10	7180	30	4779
11	6974	31	4711
12	26	32	102
13	6973	33	6997
14	6972	34	7065
15	7219	35	7175
16	7179	36	4234
17	7220		
18	6971		
19	7202		
20	2627		

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