Heredity (1974), 32 (1), 109-112

NOTES AND COMMENTS

SPECIFIC GRAVITY OF POTATO TUBERS AS A CHARACTER SHOWING SMALL GENOTYPE-ENVIRONMENT INTERACTIONS

R. J. KILLICK and N. W. SIMMONDS
Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian, EH25 9RF

Received 3.ix.73

Summary

Specific gravity (which is a measure of dry matter content) of potato tubers is an important character for the potato breeder. A survey of published and unpublished data shows that it is but little subject to genotype-environment interaction. Probably, genotype × seasons effects are slightly greater than genotypes × locations effects.

1. Introduction

The specific gravity of potato tubers is high correlated with their dry matter contents and hence with their suitability for processing uses such as chipping, crisping and canning; it is, therefore, of importance in potato breeding programmes. Plant breeding is much simplified if the expression of genetic differences between plants remains relatively constant from environment to environment, that is if there is little or no genotype-environment (hereafter GE) interaction. In this note we give evidence indicating that, unlike so many traits with which the plant breeder must work, specific gravity of potatoes meets, or comes close to meeting, this requirement.

2. Results

Table 1 shows the analysis of variance of a Scottish Plant Breeding Station trial grown in 1972. It consisted of five varieties grown in four

Table 1

Analysis of variance of SPBS trial. Data are specific gravity × 100

Source	d.f.	M.S.	P
Sites	3	4·918	<0·1%
Blocks in sites	12	0·222	—
Varieties	4	1·939	<0·1%
Varieties × sites	12	0·267	16%
Varieties × blocks in sites	48	0·180	—

blocks at each of four sites distributed from south-west England to eastern Scotland. The analysis shows that, whilst there were highly significant differences between both sites and varieties, the interaction of these factors was not significant.

Table 2 shows the joint analysis of Dutch and Scottish data for four varieties. The Dutch data were drawn from the Netherlands Rassenlijst (Anon., 1973) using conversion factors kindly provided by Ir. J. A. Hogan Esch (pers. comm.). Specific gravities were transformed to (specific gravity − 1) × 1000, a procedure which has also been applied to all subsequent data. The Scottish data were kindly provided by Dr J. L. Hardie, Department of Agriculture and Fisheries for Scotland, Scientific Services. The

TABLE 2

Analysis of variance of two-country data; from potatoes grown in Holland and Scotland

Source	d.f.	M.S.	P
Countries	1	2·628	large
Varieties	3	15·823	1-5%
Countries × varieties	3	0·467	large
Error	14	2·907	—

four varieties were: Bintje, Record, Sirtema and Duke of York. Replication varied from two to five observations per mean, so a least-squares technique was used in the analysis of variance. Varieties differed significantly in specific gravity but sites and GE effects were not significant.

Data are available from a number of unreplicated experiments, as follows:

1. 4 first early varieties grown at 3 Dutch centres.
2. 7 first early varieties grown at 2 Dutch centres.
3. 9 second early varieties grown at 3 Dutch centres.
4. 7 second early varieties grown at 2 Dutch centres.
5. 24 maincrop varieties grown at 3 Dutch centres.
6. 5 maincrop varieties grown at 2 Dutch centres.
7. 15 industrial varieties grown at 2 Dutch centres.
8. 10 varieties grown at 4 centres in New York State, U.S.A. (Nash, 1941).
9. 9 late varieties grown for 2 years at 1 centre in the U.S.A. (Akeley and Stevenson, 1943, Table 6).
10. 5 early varieties grown for 2 years at 1 centre in the U.S.A. (Akeley and Stevenson, 1943, Table 6).
11. 9 European varieties grown for 2 years at 1 centre in the U.S.A (Akeley and Stevenson, 1943, Table 6).
12. 4 varieties grown at 4 centres (Idaho, Maine, Michigan, Pennsylvania) in the U.S.A. (Akeley and Stevenson, 1943, Table 5).
13. 11 varieties grown for 2 years at 1 centre in Wisconsin, U.S.A. (Cunningham and Stevenson, 1963, Table 7).
14. 12 varieties grown at 2 centres (Louisiana and N. Dakota) in the U.S.A. (Johansen *et al.*, 1967, Table 1).
15. 9 varieties grown in 2 centres (Maine and Pennsylvania) in the U.S.A. (Akeley and Stevenson, 1943, Table 4).
16. 4 varieties grown in 4 centres (Maine, Pennsylvania, Idaho and Michigan) in the U.S.A. (Akeley and Stevenson, 1943, Table 4).
17. 40 varieties grown in 3 years at Edinburgh (Hardie, pers. comm.).
18. 7 varieties grown in 6 years at Edinburgh (Hardie, pers. comm.).
19. 9 varieties grown in one centre in Eire for 2 years (Drew and Deasy, 1939).
20. 35 Neotuberosum clones grown for 3 years at the Scottish Plant Breeding Station (Glendinning, pers. comm.).

The absence of replication prohibits examination of the significance of the interactions, but the components of variance are shown in table 3; the last column shows the interaction components as percentages of the total of all three components. These percentages range from trivial to small,

TABLE 3

Components of variance from unreplicated trials

Data (see text)	σ^2 genotypes	σ^2 environments	σ^2 interactions	Interaction percentage
1	63·25	13·92 (L)	1·58	2·0
2	9·07	17·90 (L)	0·67	2·4
3	88·81	17·50 (L)	1·27	1·2
4	56·78	19·98 (L)	0·24	0·3
5	63·78	17·64 (L)	4·04	4·7
6	60·30	24·45 (L)	0·25	0·3
7	38·29	3·48 (L)	1·05	2·5
8	40·04	87·11 (L)	14·70	10·4
9	89·97	1·35 (Y)	7·93	8·0
10	44·00	2·30 (Y)	2·90	5·9
11	60·08	— (Y)	7·72	11·4
12	0·43	3·84 (L)	0·64	13·0*
13	7·20	0·35 (Y)	2·65	25·9*
14	32·58	273·61 (L)	30·14	9·0
15	1·95	9·00 (L)	0·51	4·4
16	0·38	3·98 (L)	0·61	12·3
17	30·32	32·98 (Y)	25·42	28·7*
18	27·59	67·60 (Y)	14·03	12·8*
19	38·40	23·66 (Y)	1·33	2·1
20	33·20	122·37 (Y)	50·03	24·3*

Note: in column 3, (L) = locations, (Y) = years. In column 5 the five highest figures are marked with an asterisk; four relate to a years' interaction.

occasionally middling. There is a distinct suggestion that interactions with years are greater than interactions with places. From table 3, the range of the former is 2·1-28·7 per cent, of the latter 0·3-13·0 per cent. This would agree with one's general impression from the plant breeding literature and points to the usual conclusion that replication over years is more valuable than over places.

Nash (1941) also provides data on the dry matter content (D) of the varieties at each site. A joint regression analysis (table 4) shows that the

TABLE 4

Joint regression analysis of variance of dry matter content of U.S. potatoes (Nash, 1941)

Source	d.f.	M.S.	P
Regression	1	97·935	<0·1%
Difference in slopes	3	0·527	>20%
Difference in means	3	Not applicable	
Remainder	30	0·366	—

relationship between this and specific gravity is homogeneous for all sites. The pooled data give the regression equation

$$D = 4{\cdot}6 + 0{\cdot}211\, g$$

where g = (specific gravity − 1) × 1000. This may be compared with the regression derived from the standard equation cited by Burton (1966)

$$D = 3{\cdot}3 + 0{\cdot}211\,g.$$

The slopes clearly agree; the difference between the two intercepts may not be significant since the value a = 4·6 from Nash's data has a standard error of 0·71.

3. Conclusions

The data analysed include two experiments in which it has been possible to establish the statistical non-significance of the GE interaction. There are, in addition, 20 unreplicated trials in which the appropriate component of variance is generally small (but occasionally middling) in comparison with that of genotypes or of environments. Nash's data also show that the relationship between specific gravity and dry matter is not influenced by environment. There are, then, reasonable grounds for concluding that specific gravity of potatoes is relatively little subject to GE interaction. The testing of advanced selections at a number of sites is therefore unnecessary in breeding for high (or low) specific gravity; a single site should suffice to indicate the ranking of such selections. On the other hand, there is a suggestion that GE effects may be greater when E is represented by years rather than by sites. Further work and a certain degree of caution seem to be indicated.

All plant breeding experience says that GE interactions are often important and there is a general belief, noted above, that years often give rise to stronger interactions than places. We know of no critical review of this subject; it would be of great interest to have an authoritative survey of the relative importance of G, E and GE components for a range of crops and economic characters.

4. References

AKELEY, R. V., AND STEVENSON, F. J. 1943. Yield, specific gravity and starch content of potato tubers in a potato breeding programme. *Am. Potato J.*, *20*, 203-217.

ANON. 1973. *Rassenlijst voor landbouwgewassen*, *48*. Wageningen.

BURTON, W. G. 1966. *The Potato*, Second ed. Wageningen.

CUNNINGHAM, C. E., AND STEVENSON, F. J. 1963. Inheritance of factors affecting potato chips colour and their association with specific gravity. *Am. Potato J.*, *40*, 253-265.

DREW, J. P., AND DEASY, D. 1939. Potato growing in Ireland with particular reference to growing for industrial purposes. *J. Dep. Agric. Republ. Irel.*, *36*, 205-229.

JOHANSEN, R. H., MILLER, J. C., NEWSOM, D. W., AND FONTENOT, J. F. 1967. The influence of environment on the specific gravity, plant maturity and vigour of potato progenies. *Am. Potato J.*, *44*, 107-122.

NASH, L. B. 1941. Potato quality, IV. *Am. Potato J.*, *18*, 91-99.