The distributions of tuber sizes in droughted and irrigated crops of potato. II. Relation between size and weight of tubers and the variability of tuber-size distributions

D. K. L. MACKERRON, B. MARSHALL and R. A. JEFFERIES
Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland
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Summary

Tubers from six cultivars of potato grown in irrigated and droughted conditions were examined to show whether observed differences in grade distributions were simple consequences of differences in yield or were the results of changes in tuber shape or in the relative variability \((R_v = \sigma / \mu)\) of the distributions.

Differences in tuber shape, indicated by the relations between tuber size (mm) and weight, were statistically significant but were insufficient to cause measurable changes in the grade distributions.

There was a range of values of \(R_v\) but drought had no statistically significant effect on \(R_v\) and may only affect it by influencing the numbers of tubers set.

The main effect of drought on the distribution of tuber sizes was through its effect on total yield and hence on mean tuber size. Yield and number of tubers define a unique tuber-size distribution regardless of the soil moisture stress experienced by the crop.

Introduction

Jefferies & MacKerron (1987) reported differences between cultivars in reductions of yield caused by drought. They showed that the proportion of the total yield which reaches marketable size is dependent upon both the total yield and the total number of tubers. There were differences between cultivars in tuber populations and in one year, but not in another, drought reduced the number of tubers per unit area. The conditions under which the number of tubers set is influenced by soil moisture stress have been described by MacKerron & Jefferies (1985). MacKerron & Jefferies (1987) reported the changes in grade distribution of numbers of tubers and of yield in six cultivars. In general drought caused a downward-shift of about 7–10 mm in the centres of the size distributions of both frequency of tubers and yield.

Sands & Regel (1983) showed that a truncated Gaussian or normal curve could describe the probability distribution of yield as a function of tuber weight in the cv. Sebago, that is they used tuber weight as their measure of tuber size. The curve is characterised by two statistics: \(\mu\) a measure of the average tuber size, and \(\sigma\) the characteristic spread of the distribution. Marshall & Thompson (1986) reported that the same relation applied in cv. Record. Both investigations found that there was a conservative relationship between the spread of a distribution and the average tuber weight. That is, \(\sigma\) increased in proportion to \(\mu\). Marshall (1986) defined a relative variability parameter,
RV, as the ratio of $\sigma:\mu$ that is analogous to the coefficient of variation, and showed its independence of average tuber size ($\mu$) across 60 clones. Similar independence in the data examined here would suggest that yield and number of tubers define a unique tuber-size distribution regardless of the soil moisture stress experienced by the crop.

In this paper we report on the extent to which the differences in size distribution reported by MacKerron & Jefferies (1987) were a simple consequence of yield (and hence of average tuber size) or were due to changes in tuber shape (the relation between tuber weight and size class) or changes in the relative spread of tuber sizes ($\sigma:\mu$).

Materials and methods

The field experiments, that provided the data for this study have been described by Jefferies & MacKerron (1987). Details of cultivars, the grading of tubers and preliminary data handling are given by MacKerron & Jefferies (1988).

The influence of cultivar, year and water supply on the relation between the logarithm of mean tuber size (mm) and the logarithm of mean weight (g) in grades greater than 15 mm was analysed. In addition, in 1984 the individual tubers in each grade were weighed to provide information on the spread of tuber weights within grades.

Values of $\mu$ and $\sigma$ were determined for each distribution using the method of Sands & Regel (1983).

Results and discussion

Relation between tuber size and weight. To assist the reader to interpret these results the total yields reported by Jefferies & MacKerron (1987), were repeated by MacKerron & Jefferies (1988). Tuber malformations were absent or very rare, presumably because there was no late relief of water stress, and so they do not complicate the relations reported here.

The 1984 data from both harvests and from both treatments were combined and the ranges within each size-class, mean tuber weights and standard deviations are presented for each cultivar (Table 1). Even within one cultivar there is a wide variation within the relation between tuber size and weight. Not only do the values of means $\pm$ standard deviations of adjacent size-classes overlap in some cases but the range of tuber weights within one size-class sometimes overlaps with that in a size-class that is next-to-adjacent.

In order to quantify the relation between tuber size and weight, and to assess the effects of cultivar and treatment on it, the average tuber size (mm) in each grade and the average tuber weight in each grade (g) from each distribution were transformed to logarithms to the base 10. Over the three cultivars that were grown in both years a single linear regression on size (Fig. 1) accounted for 99.3% of the variance in weight:

$$\log_{10} W = 3.010 \log_{10} S - 3.134$$

($\pm$ 0.021) ($\pm$ 0.034)

where $W$ is average tuber weight (g), $S$ is mean tuber size (mm), and bracketed values are standard errors of the coefficients. The slope of the relation is not significantly different from 3, a cubic relation. When de-transformed the relation becomes: $W = 0.000734 S^{3.01}$. 

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