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NOTE

UNIFORMITY INDEX FOR POTATO TUBERS FROM TPS PROGENIES

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ABSTRACT

The usual rating method for determining tuber uniformity is subjective and not suitable for parametric statistical analyses. In this work, a more objective measure of uniformity is proposed. The method associates the length, width and thickness of the tubers to the three axes of the Cartesian Co-ordinate System resulting in a number of points in the three dimensional space corresponding to the respective tubers. The proximity of these points to one another, measured by mean square deviation, is used as a measure of uniformity.

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شاخص همگنی برای غده‌های حاصل از نتاج بذر حقیقی سیب زمینی

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چکیده
روش معمول تعیین میزان همگنی غده های سیب زمینی یک روش نظری بوده و برای محاسبات آماری پارامتریک مناسب نیست. در این مقاله، یک روش عینی تر برای اندازه گیری میزان همگنی ارائه شده است. در این روش طول، عرض و ضخامت غده ها با محورهای X ، Y و Z فضای سه بعدی ارتباط داده شده که نتیجه آن تعدادی نقطه در فضا به ازاء غده های مورد بررسی می باشد. قرابت نقاط مذکور با یکدیگر که توسط میانگین مربعات انحراف تعیین می گردد به عنوان شاخص همگنی منظور می شود.

INTRODUCTION

The recommended procedure by CIP for evaluating tuber uniformity is by rating from 1 to 5 (1). Although a subjective measure, it has been used by other workers (2, 5, 8). Other evaluations using rating have also been done. Werner and Peloquin (9) used rating of 1-3, with 1 indicating smooth and uniform-size tubers with shallow eyes, and 3 corresponding to small or rough tubers with deep eyes. Thompson and Mendoza (7) used rating of 1-9 for tuber smoothness; and uniformity of color, size and shape; with 9 being the most desirable. Kindane-Mariam *et al.* (3) rated uniformity of tubers separately from 1-5 regarding skin color, tuber size and tuber shape. Then they determined the overall tuber uniformity by averaging the values for the three ratings. Besides being a subjective measure, rating is not suitable for parametric statistical analyses. These analyses require data with ratio or interval scale of measurement, although analyses using rating for purposes such as estimating genetic variances (7) or genotype environment interactions (6) have been reported. Recently, an attempt was made to measure the shape of tubers objectively by calculating the ratio of the actual volume of the tuber to that of the cuboid containing it (4). The method does not involve a measure of uniformity. Moreover, it does not (and is not meant to) differentiate between shapes of tubers, since tubers of different shapes can have the same ratio of the two volumes due to varying degrees of their flatness. In the present work, attempt was made to arrive at an objective method of evaluating tuber uniformity; a method that can yield to parametric statistical analyses.

MATERIALS AND METHODS

The proposed method measures uniformity indirectly through measuring variability which can be looked upon in two senses:

1. Overall Variability

Overall variability (OV) is based on the amount of variation in length, width and thickness of the tubers. Such variation could be due to differences in shape, size, or both. If the length, width and thickness of a given tuber are associated with the three axes of the Cartesian Co-ordinate System, there will be a point in space corresponding to that particular tuber. For example, for a tuber with length, width and thickness of 12, 7 and 5 cm, respectively, there will be a point in space with its X, Y and Z at 12, 7 and 5 units from the origin. For a sample of uniform tubers, the points will cluster close to one another, whereas, for a non-uniform sample the points will spread out through a larger space. The mean square deviation of the points from the center of the cluster, corresponding to $\bar{X}$, $\bar{Y}$ and $\bar{Z}$, can be used as a measure of variability. Thus for a sample of n,

$$OV = \sum_{i=1}^{n} [(X_i-\bar{X})^2 + (Y_i-\bar{Y})^2 + (Z_i-\bar{Z})^2] /n \qquad [1]$$

In equation [1] the numerator is divided by n rather than n-3. This is to avoid the overestimation of the OV values for the smaller samples relative to larger ones, where variability of small samples of unequal size are being compared. Such cases arise when comparing, for example, variability of tubers from individual potato plants.

The procedure may be lengthy for practical purposes. In cases such as breeding programs, measurements on small samples can be used for comparing different progenies. For scientific studies, however, larger samples or entire lots may be used for accurate results.

2. Shape Variability

Shape variability (ShV) considers differences purely in shape. It is calculated by equation [1], after the Xs, Ys and Zs are adjusted for the differences in size, represented by weight.

Thus,

$$ShV = \Sigma [(X'_i-\bar{X}')^2 + (Y'_i-\bar{Y}')^2 + (Z'-\bar{Z}')^2] /n \quad [2]$$

in which $X'_i=\alpha_i X_i$, $Y'_i=\alpha_i Y_i$ and $Z'_i=\alpha_i Z_i$ and α_i is calculated as,

$$\alpha_i = \sqrt[3]{\bar{W}/W_i} \quad [3]$$

where, $\bar{W}$ and W_i represent the average weight of all the tubers in the sample and the weight of a given tuber, respectively.

To demonstrate, six samples of tubers were formed by choosing tubers of specific characteristics (Fig. 1). N°1 and N°2 are composed of tubers uniform in shape and size, one being spherical and the other oblong. N°3 and N°4 are uniform shape but variable in size. N°5 is variable in shape but uniform in size. N°6 is variable both in shape and size. The OVs and ShVs were calculated for the six samples.

RESULTS AND DISCUSSION

The scattered diagrams showing the points corresponding to tubers of the six samples in a three-dimensional space along with the corresponding OV values are presented in the top part of Fig. 1. As can be seen, in the

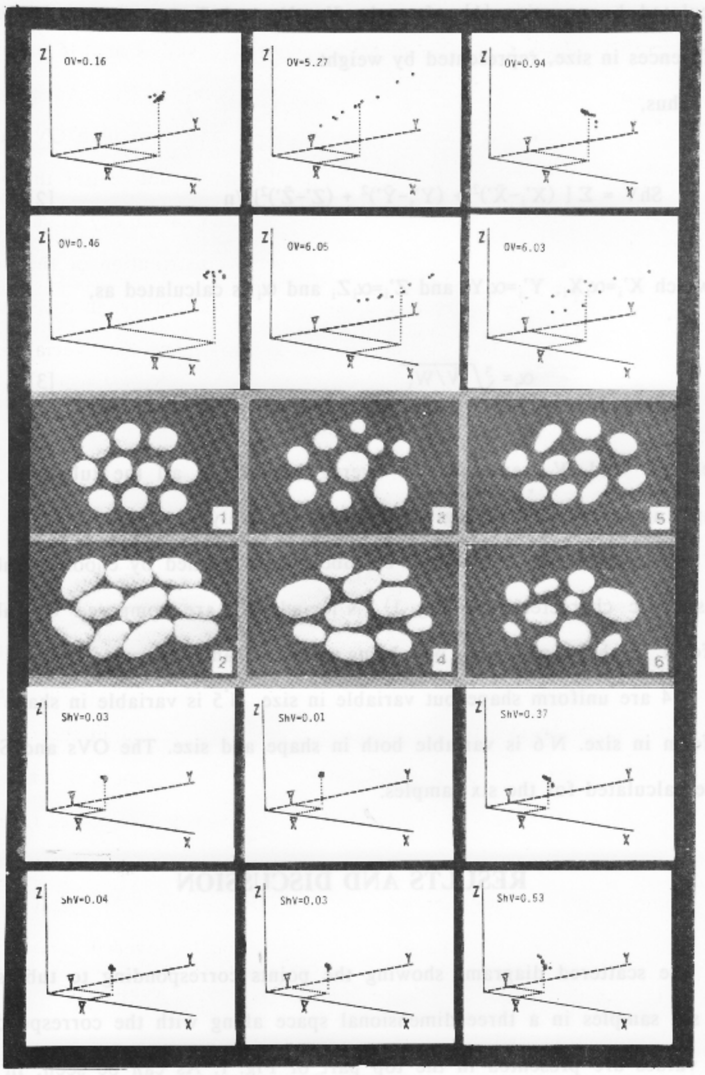

Fig. 1. Six potato samples along with the scatter diagrams representing their overall variability (top) and shape variability (bottom).

case of N°1 and N°2 the points cluster around the central point corresponding to $\bar{X}$, $\bar{Y}$ and $\bar{Z}$ and have the low OV values of 0.16 and 0.46, respectively. N°3, N°4 and N°6, are highly different in size. As a result, their points are scattered through a larger space and have high OV values. The points for N°5 due to their uniformity in size do not scatter through a large space; the small OV value is mainly due to the variability in shape.

It is interesting to note that the form of the distribution of the points in the scattered diagram reveals the cause of the variability. In cases where the points are distributed in a linear form, as in N°3 and N°4, variability is mostly due to differences in size. A spherical distribution indicates differences in shape as the cause of variability. Of course, in routine procedures the scattered diagrams need not be plotted and the OV values can be subjected to statistical analyses.

At the bottom of Fig. 1, the scattered diagram for the points after the adjustment of the corresponding dimensions for the differences in weight, along with the ShV values are presented. As expected, not much reduction from OVs to ShVs happens in the cases of N°1, N°2 and N°5 where there was little variation in size. The greatest reduction occurred in the cases of N°3 and N°4, where the variation was mostly due to differences in size.

The tubers in the above six samples can be regarded as tubers from six plants in a TPS progeny. In this case, the average of the six OVs or ShVs will indicate the within-plant variation in the progeny. The mean square deviation of the center points of the clusters from the overall center point can be calculated using equations [1] or [2] which would represent the between-plant variation.

CONCLUSION

Overall and shape variability can be measured objectively. The latter is probably more useful at the early stages of a breeding program for the elimination of the progenies with high variability in tuber shape. The former can be used at the later stages, when a good part of the variability in shape has already been removed and selection against variability in size is of greater interest.

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