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POSSIBILITY OF REDUCING THE NUMBER OF ASSESSED PLANTS FOR QUANTITATIVE CHARACTERISTICS FOR REFERENCE VARIETIES

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POSSIBILITY OF REDUCING THE NUMBER OF ASSESSED PLANTS FOR QUANTITATIVE CHARACTERISTICS FOR REFERENCE VARIETIES

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Introduction

1. For many crops it is common to take assessments/counts of 50-60 plants in each growing season. However, for some characteristics the variability between plants within the same plot may be very small compared to the variability between plots or between years. For such characteristics the discrimination power of the COY-D method may be very insensitive to the number of plants assessed in each plot. In this paper we present a method that can be used to calculate the number of plants to be assessed if a small reduction of the discrimination power can be accepted.

Method

2. The method used is based on the calculation of LSD-values. In order to calculate the LSD-value for different numbers of plants the variance components for: a) variety×year, b) plot-within-year and-block, and c) plant-within-plot has to be available. These values are then used to establish a formula for calculating the number of plants to assess each year if a slight increase in the LSD value can be accepted. We choose to calculate the number of plants to assess if it would be acceptable for the LSD value to increase by 1%, 5% or 10%.

3. The details can be described as follows: as a start, the LSD-value is calculated for a comparison using the recommended 50-60 plants per growing season. This value is called LSD_a. Given the variance component the LSD-value can be calculated as:

$$LSD_a = t * \sqrt{\frac{2}{y}\sigma^2_{y\times v} + \frac{2}{yr}\sigma^2_{plot} + \frac{1}{yn}\sigma^2_{plant} + \frac{1}{ym}\sigma^2_{plant}}$$

where

$t = 99.5\%$ fractile in the $t-$distribution

y = number of years

r = number of replication (complete blocks) in each year

n = number og assessed plants per year for the candidate variety

m = number of assessed plants per year for the reference variety

$\sigma^2_{y\times v}$ = variance component for year by variety

σ^2_{plot} = variance component for plots within year and block

σ^2_{plant} = variance component for plants within plots

4. Now we have to determine the minimum value of m that would increase the LSD-value by a certain percentage, i.e. the value of m that would yield an LSD-value of $c \times LSD_a$ (where c is the constant that makes the LSD-value increase by 1 %, 5 % or 10 %). Solving this we get:

$$\mathrm{m} = \left\{ \frac{\mathrm{y}\, c^2 LSD_a^2}{t^2 \sigma_{plant}^2} - 2\frac{\sigma_{y\times \mathrm{v}}^2}{\sigma_{plant}^2} - \frac{2}{r}\frac{\sigma_{plot}^2}{\sigma_{plant}^2} - \frac{1}{n} \right\}^{-1}$$

5. As we can not assess a fraction of a plant we have to round up the value of *m* to the nearest integer that is a multiple of the number of replicates.

6. The variance components were estimated by the REML method (see e.g. Searle et al., 1992) using the following model:

$$Y_{yrvp} = \mu + \alpha_v + A_y + B_{yr} + C_{yv} + D_{yrv} + E_{yrvp}$$

where

Y_{yrvp} = Assessed value for variety v on plant p in replicate (block) r in year y

μ and α er systematic effects for the mean and varties

A, B, C, D og E random effects, that all are asumed i.i.d. normally distributed variables with mean 0 and varinaces σ_{year}^2, $\sigma_{replicate}^2$, $\sigma_{year\times \mathrm{variety}}^2$, σ_{plot}^2 and σ_{plant}^2, respectively

Example

7. The example used is based on 13 characteristics of Yellow Mustard. The data are from 2 years (1998 and 1999) with 3 replicates. In each plot, assessments were taken on 20 plants. At the time of assessments no Test Guidelines were available for Yellow Mustard, so the Test Guidelines for Rape Seed were used. First we show the estimated variance components and the LSD-value (based on COY-D) that would result if all 3×20 assessments were taken each year (Table 1).

Table 1 Range, variance components and LSD when using all 60 assessments per year

UPOV Test Guidelines characteristic number[a] and name	Range[b]	Variance components			LSD_a
		y×v	Plot	Plant	
3 Cotyledon: width	3.1	0.04	0.03	0.70	0.64
6 Leaf: number of lobes	13.4	0.83	0.78	13.78	2.98
18 Siliqua: length	8.0	0.50	0.37	7.08	2.24
19 Siliqua: length of beak	27.4	0.52	0.48	6.42	2.30
20 Siliqua: length of peduncle	6.0	0.42	0.29	3.54	1.97
17 Plant: total length including side branches	37.4	23.03	27.11	188.02	15.43
2 Cotyledon: length	44.3	16.16	28.65	137.27	13.76
9 Leaf: width	64.3	25.55	14.54	140.72	14.88
14 Flower: width of petals	2.6	0.11	0.06	0.41	0.98
10 Leaf (6.): length of petiole	2.9	0.18	0.11	0.64	1.25
13 Flower: length of petals	45.9	46.61	81.59	194.89	22.82
8 Leaf: length (blade and petiole)	72.1	114.53	151.41	206.70	33.74
16 Plant: height at full flowering	64.0	33.68	28.18	18.47	17.12

[a] according to UPOV Test Guidelines TG/36/6. [b] range between means of varieties.

8. In the Table, the characteristics are sorted such that the characteristics which are most sensitive to reduction in the number of plants to be recorded for reference varieties are placed

at the top of the table. The reason for this sorting is to make it easier to identify the characteristics which react similarly.

9. Table 2 presents the minimum number of plants to be recorded if the different levels of acceptable increase in LSD-values do not exceed 1%, 5% or 10%. Characteristic 3, length of cotyledons, was found to be the characteristic that was most sensitive to a reduction in the number of assessed plants. The reason for this is that almost all the recorded variability for this characteristic seems to be caused by plant-to-plant variation (Table 1). At the other end of the scale we find characteristic 16, plant height at full flowering. For this characteristic, the LSD would be increased by only 1% if the number of recorded plants was reduced from 60 to 9, i.e. from 20 plants per plot to 3 plants per plot. If the number of plants per plot were reduced to just 1 plant per plot (3 plants per year) the LSD-value for this characteristic would increase by less than 5%. This is the characteristic that is most sensitive to variety×year interaction and plot-to-plot variation. When judging the effect of accepting an increase of the LSD-value, it may be valuable to compare the increase to the range of expression for the characteristic. For this characteristic, a 5% increase means an increase from 17.1 cm to 18.0 cm, about 1 cm, for a characteristic where the difference between the shortest and tallest variety is 64 cm.

Table 2 Number of plants to assess for different levels of acceptable increase in the LSD-value

UPOV TG characteristic number[a)] and name	Level of increase		
	1%	5%	10%
3 Cotyledon: width	49.7	29.2	19.0
6 Leaf: number of lobes	48.8	27.6	17.6
18 Siliqua: length	47.9	26.2	16.4
19 Siliqua: length of beak	46.4	24.0	14.7
20 Siliqua: length of peduncle	43.1	20.0	11.8
17 Plant: total length including side branches	41.3	18.2	10.5
2 Cotyledon: length	40.2	17.1	9.8
9 Leaf: width	38.4	15.5	8.7
14 Flower: width of petals	32.9	11.5	6.2
10 Leaf (6.): length of petiole	32.1	11.1	6.0
13 Flower: length of petals	30.7	10.2	5.5
8 Leaf: length (blade and petiole)	20.2	5.4	2.8
16 Plant: height at full flowering	9.0	2.0	1.0

[a)] according to UPOV Test Guidelines TG/36/6.

10. The calculations shown are valid only if the variance components will be the same for the future trials as in the trials used for estimating the variance components. As this probably will not be the case it is recommended not to reduce the number of plants as much as indicated by the shown calculations. A strategy that most probably would increase the LSD-value by less than 1% could be to:

1. continue to assess all 60 plants for characteristics assessed on cotyledons, siliquas, and leaf number of lobes
2. reduce the number of plants assessed for total plant length, leaf, and petal assessments from 60 to 45
3. reduce the number of plants assessed for plant height at full flowering from 60 to 15

Remarks

11. The calculations show that, for some characteristics, the number of assessments may be decreased without increasing the LSD-value by more than 1%. If it is acceptable to increase the LSD-value by a larger percentage, e.g. accept a 5% increase, then the number of assessments may be reduced to less than 30 plants for most characteristics.

12. In order to be able to assess the uniformity of candidate varieties, this method should only be used for reference varieties. For the candidates it is still necessary to assess 50-60 plants in each growing season.

13. The method may also have some effect on the COY-U method. In COY-U, the uncertainty used for comparing the variability of the individual candidate varieties with average variability of the relevant reference varieties is based only on the reference varieties. If the reference varieties are assessed on fewer plants than the candidates, this means that the estimated uncertainty may be expected to be too large. However, it is difficult to say how much larger this estimate will be because this estimate on uncertainty will also depend on how much the reference varieties vary and on the interaction between year and variety. The greater these sources are, the less it will influence the uncertainty.

14. All calculations were done in a SAS-macro using the procedures mixed, summary and the data-step facilities of SAS.

References

Searle, S.R., Casella, G. & McCulloch, C.E. 1992. Variance Components. John Wiley and Sons Inc. New York

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