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AN ADJUSTMENT TO THE COYD METHOD
WHEN VARIETIES ARE GROUPED WITHIN THE DUS TRIAL

Document prepared by experts from the United Kingdom

Background

1. In some crops, it is possible to use grouping characteristics to define groups of varieties such that all the varieties within a group will be distinct from all the varieties of any other group ("distinct groups"). This grouping is preserved in trial layouts so that, within a replicate, varieties in the same group are adjacent. (See TG/1/3, section 4.8 "Functional Categorization of Characteristics). Field pea is an example of such a crop.

2. In the UK the current method of analysis used in pea is to apply analysis of variance for a randomised complete block design for each trial and then apply COYD (also analysis of variance) to the variety-by-trial means. This takes no account of the grouping except that semi-leafless and conventional types are analysed separately because they are distinct types with different characteristics. In some crops, different groups are analysed separately, but in pea many groups are too small.

3. In this paper we demonstrate an adjustment to the COYD method that is both effective and relatively simple to implement. This paper is a revision of document TWC/23/8, giving more examples of application of the method.

Outline of the method

4. When grouping is possible, such that all the varieties within a group will be distinct from all varieties of any other group ("distinct groups"), comparisons are only necessary between varieties in the same group. In principle, it would be possible to analyse groups separately; in practice some groups have too few varieties. Instead we propose that the over-years analysis of variance (COYD) be adjusted to take into account the group-by-year interaction.

5. So whereas the standard COYD has terms for 'year' and 'variety', the adjusted form has terms for 'year', 'group', 'variety-within-group' and 'group-by-year'. The standard error (and LSD) is then calculated for differences between pairs of varieties within the same group. Note we assume that the same standard error is applicable within all groups.

Some detail

6. With COYD, the analysis of variance is based on variety-by-year means for two or three years depending on the crop. Usually only varieties present in all years are considered. The analysis of variance includes effects for year and variety. The standard error, SED_{COYD}, for the difference between two varieties is given by:

$$SED_{COYD} = \sqrt{\frac{2}{n} RSS_{COYD}}$$

where n is the number of years and RSS_{COYD} is the residual sum of squares from the analysis of variance (based on means).

7. We propose that an extra factor, the group-by-year interaction, is included in the analysis of variance. So in GenStat terminology (Payne *et al.*, 2008, *The Guide to GenStat Release 11, Part 2: Statistics*. VSN International, Hemel Hempstead) we have:

Block structure: Year + Year.Group
Treatment structure: Group/Variety

8. The standard error, SED_{adj}, for the difference between two varieties in the same group is given by:

$$SED_{adj} = \sqrt{\frac{2}{n} RSS_{adj}}$$

where RSS_{adj} is the residual sum of squares from the analysis of variance that includes the group-by-year interaction term. Unlike SED_{COYD}, SED_{adj} excludes variability due to the interaction between varietal groups and years. We believe this is reasonable as candidate varieties are only being assessed for distinctness from varieties in their group.

Application 1: historical data

9. This adjustment method has been applied to UK pea DUS trial data from 1995-2004. Comparisons were made between standard COYD and the group-adjusted COYD on pairs of consecutive years. Semi-leafless and conventional varieties were analysed separately. Only one group was represented in 2002-3 and 2003-4 for the conventional type so these were not analysed.

10. Tables 2 and 3 show the decreases in the standard errors (or LSDs) for the semi-leafless and conventional types respectively. A list of characteristics is shown in Table 1.

11. In nearly all cases (81% for semi-leafless and 73% for conventional), there is a decrease in the standard error when the adjustment is used. These correspond to cases where there is a group-by-year effect (results not shown). Often the reduction is sizeable. In those cases where there is no reduction, the increase in standard error is generally negligible. A notable exception is for conventional varieties in 2000-1. We suggest that this is partly due to the low number (7) of residual degrees of freedom for the adjusted method in this case.

Application 2: recent data in more detail

11. The adjusted COYD method was applied in UK pea DUS decision-making during 2007 and compared with standard COYD.

12. Table 4 shows the decrease in standard errors for semi-leafless varieties. As well as generally decreasing the COYD LSDs, the adjustment resulted in more differences between candidate varieties and close reference varieties. Two candidates were found to be distinct only when the adjustment was used.

13. We now look at the results for characteristic 01 in more detail. Figure 1 shows the group means for each year. The group-by-year interaction is evident. In particular, group G shows a smaller increase from 2006 to 2007 than the other groups; this group also has a lower overall mean. Group sizes were 70, 8, 31, 1, 4, 7 for the groups labelled A, C, D, F, G and I respectively.

14. Figure 2 shows the residuals by group from the unadjusted and the adjusted COYD ANOVAs, demonstrating how the overall residual is reduced.

Software

15. A software module has been written to allow SASA to apply this method routinely. This is based on the DUST package's TVRP module. There are plans to integrate this module in DUST's Windows interface this year. This modified version of DUST will only be made more widely available with the agreement of the TWC.

Conclusions

16. We have proposed a method for adjusting COYD when grouping characteristics are used to identify distinct groups of varieties. It is appropriate when some group sizes are too small to allow separate analyses. Application to a number of datasets for pea has shown that this should produce considerable benefits for some characteristics. The method should not be used if the resulting residual degrees of freedom drops to below, say, 12. This method is relatively easy to implement.

Table 1: *List of characteristics used in UK Pea DUS tests*

Characteristic no.	Characteristic
01	Plot height at 80% flowering
03	Petiole length
07	Peduncle length (stem to first pod)
10	Days to first flower
12	Days to 80% flowering
25	Flower standard width
36	Leaflet widest point to base
41	Stipule length
44	Stipule width
46	Foliage colour (intensity)
50	Leaflet length
51	Leaflet width
71	Number of nodes up to first fertile node
72	Maximum leaflet number
74	Pod length
75	Pod width
76	No seeds & ovules per pod
80	100 Seed weight (dry)
88	Plot height at harvest
100	Stipule area
101	Stipule: length of lobe below axil
103	Stipule: length from axil to tip

Table 2: *Reduction in SED given by the adjusted-COYD method compared to the standard COYD method: semi-leafless varieties*

	Pairs of years								
	95-6	**96-7**	**97-8**	**98-9**	**99-0**	**00-1**	**01-2**	**02-3**	**03-4**
No. varieties	99	111	129	118	147	148	157	170	148
No. groups	7	10	12	6	9	8	8	10	9
Min. no. per group	1	1	1	1	1	2	1	1	1
Max. no. per group	57	64	76	71	93	93	113	124	105
Characteristic	**SED decrease from conventional COYD to group-adjusted COYD (%)**								
01	10.3	8.1	12.5	0.3	-0.9	1.4	1.4	0.4	0.5
03	0.1	5.5	7.2	7.5	4.6	8.8	1.9	2.9	-0.3
07	3.8	18.1	1.8	12.3	9.1	5.7	3.5	2.9	-2.4
10	2.9	0.3	5.3	7.3	2.7	2.2	1.4	3.0	1.6
12	4.1	7.4	11.4	6.3	2.5	2.0	4.5	5.8	7.4
25	4.0	6.6	6.4	3.5	16.2	5.0	0.3	5.9	1.5
41	19.5	19.7	2.1	10.1	5.0	3.1	3.1	6.5	1.9
44	12.2	21.5	1.8	13.8	1.8	2.1	5.2	6.7	3.3
46	12.0	37.3	18.4	3.0	7.2	2.6			
71	3.4	-0.2	11.2	1.4	6.4	12.6	6.6	0.6	2.3
74	-1.2	7.9	2.9	0.7	4.4	3.5	2.9	-1.1	-0.6
75	3.4	18.9	11.9	1.9	9.8	7.6	4.8	2.2	-0.4
76	6.1	7.8	1.2	1.0	2.7	2.0	3.2	-0.2	1.2
80		25.2	12.4	4.1	1.1	22.5	3.8	8.7	3.7
88			3.5	10.6	1.3	0.5	0.8	4.6	8.3

Table 3: *Reduction in SED given by the adjusted-COYD method compared to the standard COYD method: conventional varieties*

	Pairs of years						
	95-6	**96-7**	**97-8**	**98-9**	**99-0**	**00-1**	**01-2**
No. varieties	27	14	19	28	18	11	19
No. groups	5	3	3	4	2	4	3
Min no. per group	2	1	1	3	7	1	1
Max no. per group	13	8	11	13	11	6	13
Characteristic	**SED decrease from conventional COYD to group-adjusted COYD (%)**						
01	-4.4	-0.9	16.7	2.8	6.4	19.5	1.1
07	20.9	-2.5	7.9	21.6	39.9	21.0	13.6
10	9.3	16.9	15.3	22.3	45.8	18.9	26.6
12	11.9	16.4	7.7	12.3	34.1	24.9	32.6
25	8.1	-1.9	18.6	0.6	32.2	31.4	0.3
36	22.3	-0.7	1.0	3.5	2.7	13.4	-3.8
41	17.6	21.8	7.1	6.4	11.1	38.9	26.5
44	0.3	25.6	8.8	8.9	0.0	7.0	27.6
46	13.7	20.8	6.1	27.5	10.1	-9.1	1.6
50	33.1	10.9	13.3	-2.2	14.2	32.9	12.7
51	36.4	23.3	12.6	3.2	5.6	44.2	11.7
71	14.9	-6.3	0.4	-1.9	38.9	1.9	7.4
72	1.0	-4.7	-2.4	11.5	-0.9	-8.4	9.6
74	7.1	-2.1	-0.2	19.8	37.3	-11.2	10.4
75	23.8	4.2	-1.2	2.0	28.5	1.0	-3.8
76	17.7	-2.3	-1.0	-1.3	-3.1	1.3	-4.5
80	24.9	5.3	15.6	-2.9	-2.7	-4.6	13.2
88			11.9	6.2	-1.7	47.6	-3.2

Table 4: *Reduction in SED given by the adjusted-COYD method compared to the standard COYD method: 2006/7 decisions*

Characteristic	**Decrease in SED %**
01	28
03	2
07	1
10	4
12	10
25	4
41	6
44	5
71	6
74	2
75	6
76	2
80	10
88	5
100	5
101	1
103	5

Figure 1: *Yearly means for each group for characteristic 01*

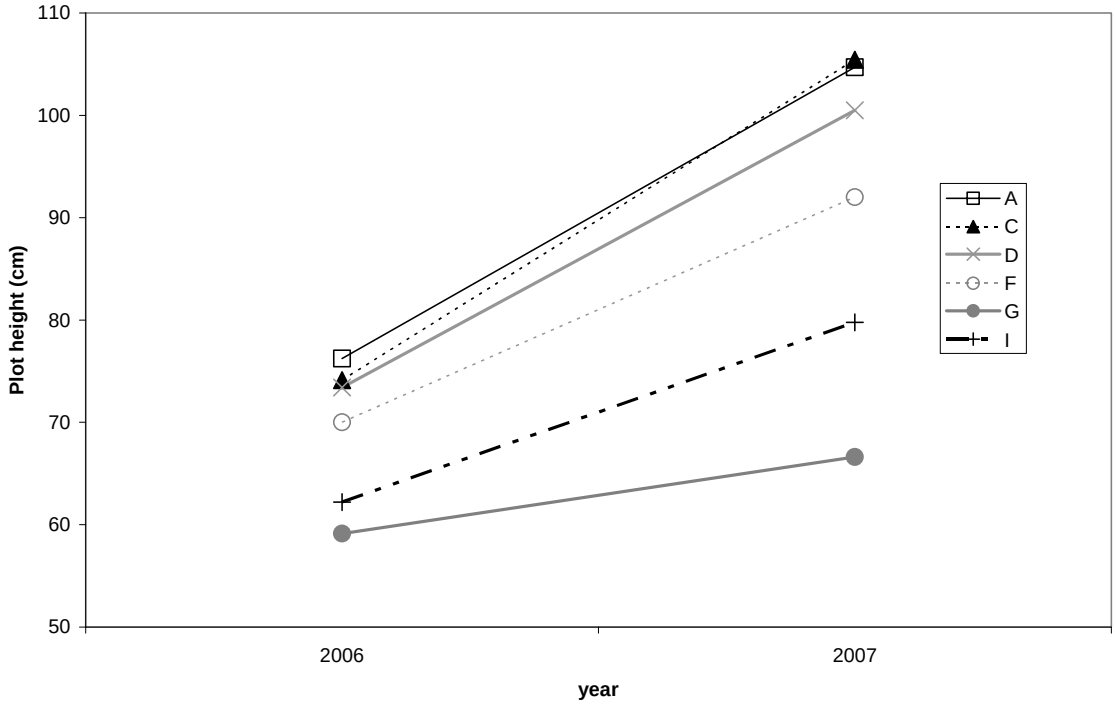
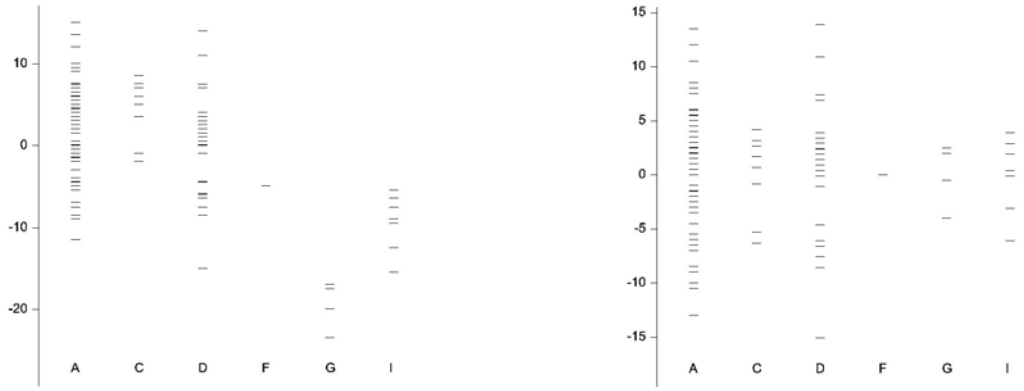


Figure 2: *Differences between residuals in 2006 and 2007: residuals from COYD analyses of variance (a) unadjusted and (b) adjusted for groups for characteristic 01*



(a) (b)

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