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PRELIMINARY REPORT ON THE EFFICIENCY OF INCOMPLETE BLOCK DESIGNS IN DUS HERBAGE TRIALS

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Summary

1. A preliminary report on the use of incomplete block designs in the eight UK DUS herbage trials planted in 2001 is given. It is reported that the early recorded characteristics which were identified as showing evidence of spatial dependence in a previous investigation, were more efficiently analysed by incomplete blocks analysis than they were by a complete blocks analysis.

Introduction

2. Incomplete blocks have been used for many years in VCU trials. In these trials their advantage over complete block trials is undeniable. They have also been tried in recent years in various DUS trials. The outcomes of these trials have been mixed. For example, Kristiansen (1998, 1999, 2000) reported on the efficiency of resolvable incomplete block designs in DUS trials on spring rape, winter rape, and yellow mustard in Denmark, and Pilarcyzk (1999, 2000, 2001) reported relatively low efficiency of such designs in french bean and field pea in Poland.

3. Until recently incomplete block designs have not been used in UK herbage DUS trials. However, data from these trials have been investigated for the presence of spatial dependence (Watson, 2001). Evidence of spatial dependence was found in some characteristics, in particular those measuring the overall dimensions of the plants and especially late season characteristics. As the efficiency of analysis of such characteristics can be improved by using incomplete block designs instead of complete block designs, the information on spatial dependence was used to determine the optimal size of the incomplete blocks. This was on average 9 plots per incomplete block. The increases in efficiency expected through using and analysing for incomplete block designs instead of complete block designs were also predicted.

4. Because, apart from a little added effort in designing the trials, there were no extra costs to planting trials as incomplete block designs instead of complete block designs, the DUS spaced plant herbage trials planted at Crossnacreevy, Co. Down in 2001 were designed as alpha (incomplete block) designs (Patterson & Williams, 1976). Alpha designs are resolvable, meaning that the incomplete blocks can be segregated to form complete replicates of the varieties. As a result, data from alpha designs can either be analysed using an incomplete blocks analysis or using a complete blocks analysis. As the variances of the variety means are a measure of their precision, comparison of the variances by the two methods of analysis gives the efficiency of using the alpha design compared to a complete blocks design.

5. To date only six or fewer characteristics have been recorded on the trials planted in 2001. This note reports on the efficiencies of using incomplete blocks compared to complete blocks analysis for these characteristics in these trials.

Description of the DUS herbage trials planted in 2001

6. Eight DUS spaced plant herbage trials were planted in 2001. These were the tetraploid perennial ryegrass (Prg tet), tetraploid italian ryegrass (Irg tet), diploid italian ryegrass (Irg dip), perennial ryegrass diploid amenity, perennial ryegrass diploid forage, hybrid ryegrass, timothy, and white clover trials. The efficiency factors of the trials' designs and the numbers of varieties are listed in Table 1. They were planted according to alpha designs with 9 plots per incomplete

block, with 10 plants per plot, and with six replicates. The replicates were laid out as shown in Figure 1. Where a replicate had more than one row of plots the randomisation followed a serpentine pattern, this ensured that plots within an incomplete block would be near to each other.

The data and the results of the analysis

7. To date between two and six characteristics have been recorded on each trial. They have been analysed using both an incomplete blocks analysis and a complete blocks analysis, i.e. ignoring the incomplete blocks. The efficiency of the incomplete blocks analysis is taken to be the ratio expressed as a percent of the average variance of variety means from the complete block analysis to the average variance from the incomplete block analysis. It is a measure of the balance between the gains in efficiency due to better control of the spatially dependent variation through using incomplete blocks and the losses in efficiency due to the comparison of means of varieties that are not all in the same block. Table 1 gives the efficiency of the incomplete blocks analysis for each of the nine characteristics recorded early on the eight trials.

8. The ratio expressed as a percent of the complete block analysis residual mean square to the incomplete block analysis residual mean square is given in Table 2 for each of the nine characteristics recorded early on the eight trials. Values over 100 indicate characteristics for which incomplete blocks give better control of spatially dependent variation. This is irrespective of whether these gains in efficiency outweigh losses due to the comparison of means of varieties that are not all in the same block.

Discussion

9. Six of the nine characteristics recorded early on the 2001 planted trials have been recorded on more than one trial. In three of these six (characteristics 60, 70 & 5) it was more efficient to analyse using an incomplete blocks analysis than it was to ignore the blocks and do a complete blocks analysis. This was the case in all trials except the Irg dip trial, where only character 70 was more efficiently analysed using an incomplete blocks analysis.

10. The ratios of complete block analysis to incomplete block analysis residual mean squares show that for all characteristics except characteristics 1 and 20 incomplete blocks analysis consistently gave greater control of variation and hence a smaller residual mean square than was got by using complete blocks analysis. This might suggest that these characteristics are not purely genetically determined, but are affected by their environment, and hence exhibit some form of spatial dependence which is controlled by the incomplete blocks. Although only in those characteristics with values greater than 100 in Table 1 is the spatial dependence strong enough to make the gain in efficiency through control of variation by the incomplete blocks greater than the loss in efficiency caused by comparisons of varieties across different blocks.

11. These results agree reasonably well with the findings of the original investigation. In this, characteristics 60, 70 & 5 were the only early recorded characteristics studied for evidence of spatial dependency and then only in the Prg tet, Irg tet, and Irg dip trial types (Table 3). Like in this study, characteristics 60, 70 & 5 were found to be spatially dependent, but not in all trials, and, as in this study, there were the fewest spatially dependent characteristics, implying the weakest spatial dependency in the Irg dip trials.

12. The more efficient analysis of characteristics 60, 70 & 5 using incomplete blocks analysis compared to complete blocks analysis implies that that the 2001 trials' variety means from the incomplete blocks analysis for these characteristics will be more precise, i.e. have smaller variances and standard errors. The data from the mid and late season recorded characteristics must yet be studied to see whether, as the original investigation suggests, some will also be more efficiently analysed by incomplete blocks analysis.

13. Data from future trials will be needed to determine whether similar improvements in efficiency occur routinely and whether this will result in these characteristics being more useful in declaring varieties distinct using the COYD criterion. The ultimate goal is that a more efficient analysis of the data, such as is enabled in this case by the use of incomplete block designs, will either allow:-

- a reduction in trial sizes and hence costs while maintaining the effectiveness of the DUS decision making process or
- an increased level of discrimination between varieties at the same cost.

14. The choice between these two will depend on the needs of both the testing authorities and the breeders. Further, for the first option to happen, efficiency gains will have to be made in both the distinctness and the uniformity analyses.

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Figure 1. Showing the ordination of the six replicates, the plots and the guard rows in each of the UK DUS spaced plant trials planted in 2001 for (a) Amenity, Prg tet, Forage, (b) Irg dip, Irg tet, Hybrids, Timothy, (c) Clover. The diagram is not drawn to scale and the numbers of plots per replicate are not exact

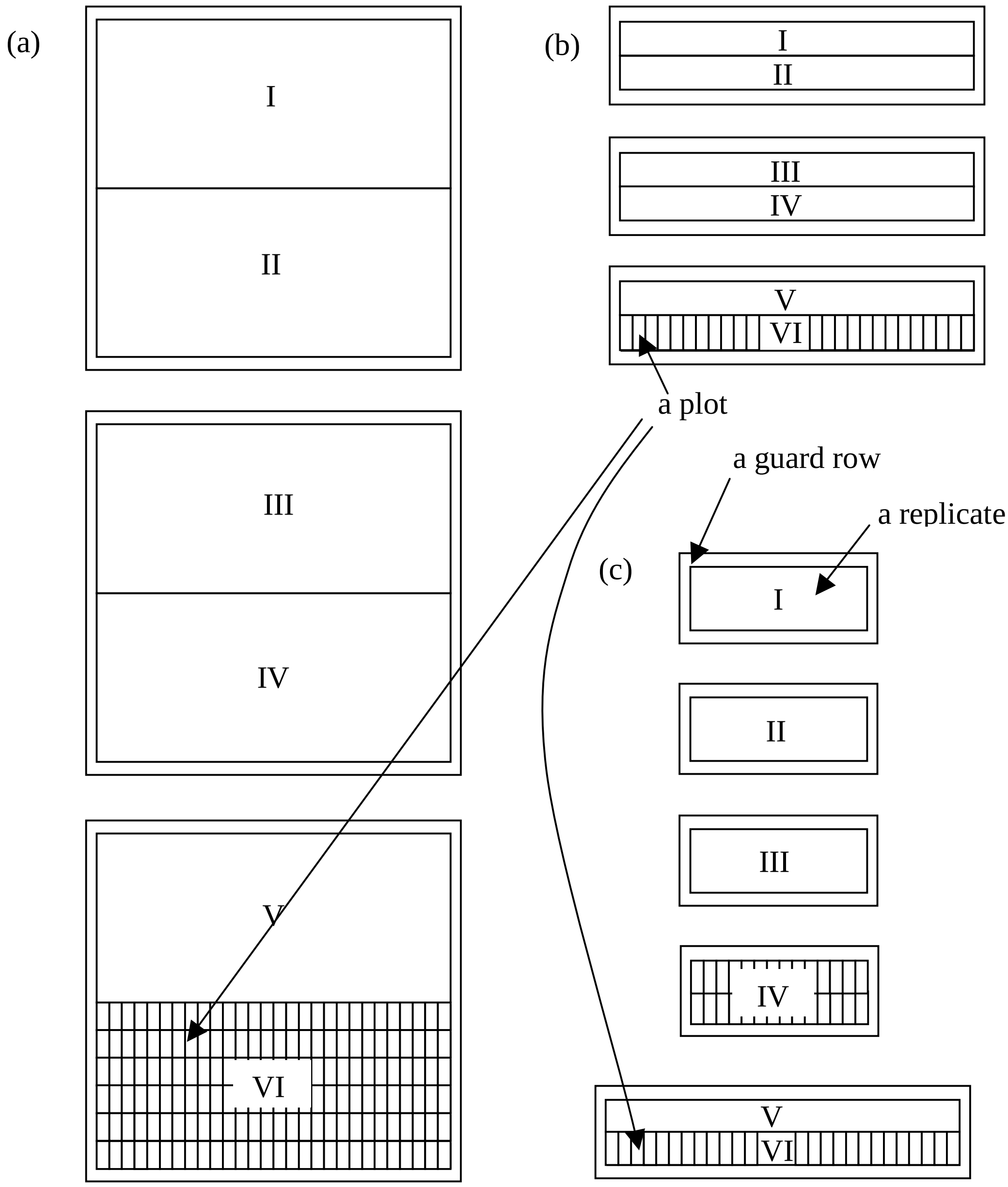

Table 1. Showing design details and the efficiencies of incomplete block analysis compared to complete block analysis for early recorded characteristics in UK DUS spaced plant herbage trials planted in 2001.

Trial	Design's efficiency factor	No of varieties	Characteristic code 1	4	9	60	70	5	34	21	20
Amenity	0.878846	187		93	111	110	115	113			
Clover	0.886589	104	91								86
Timothy	0.889852	74	88	95				104	103	97	
Hybrids	0.889772	89	81	105	90	108	115	113			
Irg dip	0.887264	93	86	99	108	96	100	98			
Irg tet	0.889678	79	82	90	89	119	126	133			
Prg tet	0.879378	174		98	103	103	129	120			
Forage	0.875135	287		104	95	100	133	113			
Average			85.5	97.7	99.4	106.1	119.6	113.3	103.2	96.7	86.5

Characteristic code	Description of characteristic
1	Heading year of sowing
4	Angle in year of sowing
9	Spring angle
60	Natural spring height
70	Natural spring width
5	Pulled spring height
34	Width of longest vegetative leaf
21	Leaf colour
20	% of plants with cyanogenesis

Table 2. Showing the ratio expressed as a percent of the complete block analysis residual mean square to the incomplete block analysis residual mean square for early recorded characteristics in UK DUS spaced plant herbage trials planted in 2001.

Trial	1	4	9	60	70	5	34	21	20
Amenity		107	128	127	132	130			
Clover	103								98
Timothy	101	109				119	119	111	
Hybrids	95	123	105	127	135	132			
Irg dip	102	118	129	115	119	116			
Irg tet	97	106	105	140	148	157			
Prg tet		112	119	118	149	138			
Forage		121	110	117	154	131			
Average	99.5	113.8	116.0	123.8	139.5	131.9	118.5	111.1	98.1

Table 3. Predicted efficiency of incomplete blocks analysis and (in brackets) predicted optimal incomplete block sizes for a trial with 96 varieties in six replicates and 10 plants per plot. This is shown for the early recorded characteristics where the trial types showed evidence of spatial dependence in the original investigation

	Characteristic code		
Trial type	**60**	**70**	**5**
Irg dip		112 (7)	
Irg tet		180 (10)	105 (11)
Prg tet	129 (9)	146 (14)	149 (7)

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