E

TWC/21/8
ORIGINAL: English
DATE: June 4, 2003

UPOV

INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS

GENEVA

TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

Twenty-First Session
Tjele, Denmark, June 10 to 13, 2003

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

Document prepared by experts from the United Kingdom

Summary

1. An interim report on the use of incomplete block designs in the eight UK DUS herbage trials planted in 2001 and 2002 is given. It is reported that most characteristics showed evidence of being affected by the environment in that incomplete blocks analysis gave greater control of variation than did complete blocks analysis. However, in only a few of the characteristics did the gain in efficiency through control of variation by the incomplete blocks outweigh the loss in efficiency caused by comparisons of varieties across different blocks. These characteristics tended to be ones that measure the overall dimensions of the plant.

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.

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 and 2002 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. This document reports on the efficiencies of using incomplete blocks compared to complete blocks analysis for the primary characteristics recorded on the trials planted in 2001 and the characteristics recorded early on the trials planted in 2002. It follows the preliminary report by Watson (2002) on the trials planted in 2001.

Description of the DUS herbage trials planted in 2001 and 2002

6. Eight spaced plant herbage DUS trials were planted in each of 2001 and 2002. 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 Tables 2 and 4. 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. Between 15 and 19 primary characteristics were recorded on the trials planted in 2001 and between 2 and 5 characteristics have been recorded to date on the trials planted in 2002. These characteristics are listed in Tables 1 and 4. 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. Tables 2 and 4 give the efficiency of the incomplete blocks analysis for the characteristics recorded on each trial.

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 Tables 3 and 4 for the characteristics recorded on each trial. 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. The ratios of complete block analysis to incomplete block analysis residual mean squares in Tables 3 and 4 show that for nearly all the recorded characteristics in all trials incomplete blocks analysis gave greater control of variation and hence a smaller residual mean square than was obtained by using complete blocks analysis. This suggests that the majority of characteristics are not purely genetically determined, but are also affected by the plants' environment. Hence they exhibit some form of spatial dependence, which is controlled by the incomplete blocks. As would be expected, the characteristics "percentage presence of awns" and "percentage with cyanogenesis" seem to be an exception to this and possibly also "glume length".

10. From the efficiencies shown in Tables 2 and 4, it can be seen that in only a few of the characteristics is any 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. As found by Watson (2001), the characteristics which indicate this stronger spatial dependence tend to be those which reflect the overall dimensions of the plant, such as plant heights and widths and lengths of longest leaves etc..

11. The more efficient analysis of some characteristics using incomplete blocks analysis compared to complete blocks analysis implies that that the variety means from the incomplete blocks analysis for these characteristics will be more precise, i.e. have smaller variances and standard errors. However, 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. For example, once the remaining characteristics have been recorded on the trials planted in 2002, a comparison can be made of the distinctness decisions resulting from applying the COYD criterion to two year data where the means are either all from a complete blocks analysis or from an incomplete blocks or a complete blocks analysis depending on the characteristic.

REFERENCES

PATTERSON, H. D. & WILLIAMS, E. R. (1976). A new class of resolvable incomplete block designs. *Biometrika,* **63**, 83-90.

KRISTENSEN, K. (1998). Efficiency of different designs in spring rape. TWC/16/12, UPOV, Geneva.

KRISTENSEN, K. (1999). Efficiency of incomplete block designs in spring rape and yellow mustard. TWC/17/8, UPOV, Geneva.

KRISTENSEN, K. (2000). Efficiency of incomplete block designs in winter rape, spring rape and yellow mustard. TWC/18/4, UPOV, Geneva.

PILARCZYK, W. (1999). On efficiency of resolvable incomplete block designs in DUS trial on french bean varieties. TWC/17/2, UPOV, Geneva.

PILARCZYK, W. (2000). The efficiency of different designs in DUS trial on pea varieties. TWC/18/6, UPOV, Geneva.

PILARCZYK, W. (2001). The efficiency of incomplete block designs in DUS trial on pea varieties. TWC/19/3, UPOV, Geneva.

WATSON, S. (2001). Spatial dependency and block designs. TWC/19/4, UPOV, Geneva.

WATSON, S. (2002). Preliminary report on the efficiency of incomplete block designs in DUS herbage trials. TWC/20/4, UPOV, Geneva.

Figure 1. Showing the ordination of the six replicates, the plots and the guard rows in each of the UK DUS spaced plant trials for (a) Amenity, Perennial ryegrass tetraploid (Prg tet), and Forage planted in 2001, Forage, Amenity and Prg Tet planted in 2002, (b) diploid italian ryegrass (Irg dip), tetraploid italian ryegrass (Irg tet), Hybrids and Timothy planted in 2001, Irg Tet, Irg Dip, Hybrids and Clover planted in 2002, (c) Clover planted in 2001, (d) Timothy planted in 2002. The diagram is not drawn to scale and the numbers of plots per replicate are not exact.

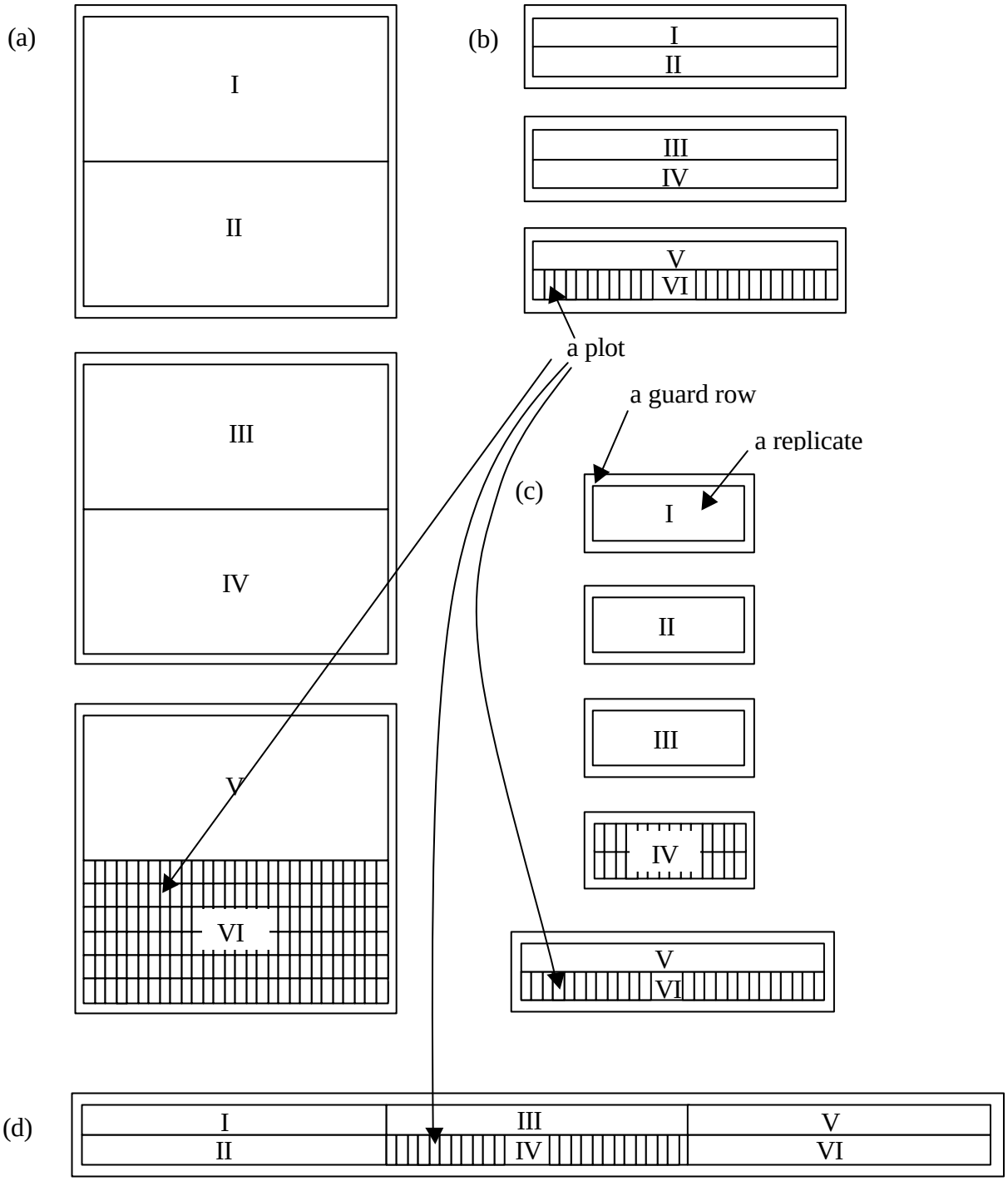

Table 1. Characteristic codes and descriptions for the characteristics recorded in UK DUS spaced plant herbage trials (except White Clover)

Characteristic code	Abbreviated description	Description of characteristic
1	HEAD YOS	Number of heads in year of sowing
4	ANG YOS	Angle in year of sowing
5	SP.HGHT	Pulled spring height
8	DATE EE	Date of ear emergence
9	SP. ANG	Spring angle
10	HGHT EE	Height at ear emergence
11	WIDTH EE	Width at ear emergence
14	LGTH FL	Length of flag leaf
15	WIDTH FL	Width of flag leaf
16	F.L.ATT	Flag leaf attitude
17	LLSEE+30	Length of longest stem at ear emergence + 30 days
21	LEAF COL	Leaf colour
24	EAR LGTH	Ear length
25	%AWNS	Percentage of plants with awns present
31	SPKLT NO	Number of spikelets
33	LGHBSP+A	Length of basal spikelet including awn
34a	GLUMLGTH	Glume length
34b	WIDTH VL	Width of longest vegetative leaf
35	LGHBSP-A	Length of basal spikelet excluding awn
36	L.P.L.EE	Length of penultimate leaf at ear emergence
37	W.P.L.EE	Length of penultimate leaf at ear emergence
38	AWNLGTH	Awn length
60	NAT.SPHT	Natural spring height
70	SP.WDTH	Natural spring width

Note Char 34a For trials other than Timothy
Char 34b For Timothy only

Table 2. Showing design details and the efficiencies* of incomplete block analysis compared to complete block analysis for:-

a) characteristics recorded in UK DUS spaced plant herbage trials (except White Clover) planted in 2001

b) early recorded characteristics in UK DUS spaced plant herbage trials (except White Clover) planted in 2002.

a) 2001 planted trials		Trial 1 Forage	Trial 5 Prg tet	Trial 6 Irg tet	Trial 7 Irg dip	Trial 8 Hybrids	Trial 24 Amenity	Trial 10 Timothy
	No Varieties	254	167	60	72	69	70	175
	Efficiency Factor of the design	0.8751	0.8794	0.8897	0.8873	0.8898	0.8899	0.8788
Char	Char name							
1	HEAD YOS	-	-	82	86	81	-	88
4	ANG YOS	**103**	97	90	**100**	**105**	93	95
5	SP.HGHT	**112**	**119**	**133**	98	**113**	**113**	**104**
8	DATE EE	**105**	94	92	81	96	93	**120**
9	SP. ANG	95	**103**	88	**108**	90	**111**	-
10	HGHT EE	99	93	**116**	96	**105**	94	**134**
11	WIDTH EE	**107**	90	**100**	91	92	**107**	88
14	LGTH FL	**100**	94	**104**	92	**108**	**106**	93
15	WIDTH FL	92	91	88	92	93	91	94
16	F.L.ATT	-	-	-	-	-	-	94
17	LLSEE+30	**114**	92	**106**	86	93	99	**102**
21	LEAF COL	-	-	-	-	-	-	97
24	EAR LGTH	92	88	86	89	90	93	93
25	%AWNS		85	80	84	85	28	-
31	SPKLT NO	84	86	87	85	84	87	-
33	LGHBSP+A	-	-	85	87	-	-	-
34a	GLUMLGTH	89	94	82	86	85	86	-
34b	WIDTH VL	-	-	-	-	-	-	**103**
35	LGHBSP-A	91	93	87	86	95	90	-
36	L.P.L.EE	-	-	-	-	-	-	**104**
37	W.P.L.EE	-	-	-	-	-	-	95
38	AWNLGTH	-	-	91	90	-	-	-
60	NAT.SPHT	**100**	**102**	**118**	97	**108**	**110**	-
70	SP.WDTH	**132**	**128**	**126**	**100**	**115**	**115**	-

b) 2002 planted trials		Trial 1 Forage	Trial 5 Prg tet	Trial 6 Irg tet	Trial 7 Irg dip	Trial 8 Hybrids	Trial 24 Amenity	Trial 10 Timothy
	No Varieties	274	170	67	70	74	74	186
	Efficiency Factor of the design	0.8754	0.8800	0.8905	0.8905	0.8897	0.887	0.8788
Char	Char name							
1	HEADYOS	-	-	93	89	88	-	**117**
4	ANG YOS	90	**111**	99	86	89	95	91
5	SP.HGHT	**148**	**160**	-	-	-	**168**	**114**
9	SP. ANG	**100**	**100**	95	87	88	**101**	-
21	LEAF.COL	-	-	-	-	-	-	98
60	NAT.SPHT	**141**	**138**	**121**	96	94	**174**	-
70	SP.WDTH	**141**	**139**	**103**	**111**	94	**138**	-

Table 3. Showing the ratio expressed as a percent of the complete block analysis residual mean square to the incomplete block analysis residual mean square for:-

a) characteristics recorded in UK DUS spaced plant herbage trials (except White Clover) planted in 2001

b) early recorded characteristics in UK DUS spaced plant herbage trials (except White Clover) planted in 2002.

a) 2001 planted trials		Trial 1 Forage	Trial 5 Prg tet	Trial 6 Irg tet	Trial 7 Irg dip	Trial 8 Hybrids	Trial 24 Amenity	Trial 10 Timothy
Char	Char name							
1	HEAD YOS	-	-	97	**102**	95	-	**101**
4	ANG YOS	**120**	**112**	**106**	**118**	**123**	**107**	**109**
5	SP.HGHT	**131**	**138**	**157**	**116**	**133**	**130**	**119**
8	DATE EE	**122**	**109**	**109**	97	**112**	**107**	**138**
9	SP. ANG	**111**	**119**	**105**	**129**	**105**	**128**	-
10	HGHT EE	**115**	**108**	**137**	**114**	**123**	**108**	**154**
11	WIDTH EE	**125**	**104**	**118**	**109**	**107**	**123**	**101**
14	LGTH FL	**117**	**109**	**123**	**109**	**126**	**122**	**106**
15	WIDTH FL	**108**	**106**	**104**	**109**	**109**	**105**	**108**
16	F.L.ATT	-	-	-	-	-	-	**108**
17	LLSEE+30	**133**	**107**	**125**	**102**	**109**	**113**	**117**
21	LEAF COL	-	-	-	-	-	-	**111**
24	EAR LGTH	**107**	**102**	**102**	**105**	**105**	**107**	**107**
25	%AWNS	-	**100**	96	**100**	99	-	-
31	SPKLT NO	98	99	**103**	**101**	99	**100**	-
33	LGHBSP+A	-	-	**101**	**103**	-	-	-
34a	GLUMLGTH	**104**	**109**	97	**102**	**100**	99	-
34b	WIDTH VL	-	-	-	-	-	-	**103**
35	LGHBSP-A	**106**	**108**	**103**	**102**	**112**	**104**	-
36	L.P.L.EE	-	-	-	-	-	-	**120**
37	W.P.L.EE	-	-	-	-	-	-	**109**
38	AWNLGTH	-	-	**108**	**107**	-	-	-
60	NAT.SPHT	**117**	**118**	**140**	**115**	**127**	**127**	-
70	SP.WDTH	**154**	**149**	**148**	**119**	**135**	**132**	-

b) 2002 planted trials		Trial 1 Forage	Trial 5 Prg tet	Trial 6 Irg tet	Trial 7 Irg dip	Trial 8 Hybrids	Trial 24 Amenity	Trial 10 Timothy
Char	Char name							
1	HEADYOS	-	-	**106**	**102**	**101**	-	**141**
4	ANG YOS	**106**	**127**	**113**	98	**102**	**111**	**109**
5	SP.HGHT	**175**	**184**	-	-	-	**195**	**137**
9	SP. ANG	**118**	**114**	**108**	**100**	**101**	**117**	-
21	LEAF.COL	-	-	-	-	-	-	**118**
60	NAT.SPHT	**166**	**158**	**138**	**110**	**108**	**203**	-
70	SP.WDTH	**166**	**159**	**118**	**127**	**108**	**160**	-

Table 4. Showing

1) design details and the efficiencies* of incomplete block analysis compared to complete block analysis
2) the ratio expressed as a percent of the complete block analysis residual mean square to the incomplete block analysis residual mean square

for:-

a) characteristics recorded in UK DUS spaced plant White Clover trial planted in 2001
b) early recorded characteristics in the UK DUS spaced plant White Clover trial planted in 2002.

a) 2001 planted trial

	Trial 12 Clover
No Varieties	98
Efficiency Factor of the design	0.8866

Char	Char name	Character description	Efficiency*	Ratio
1	FLWRYOS	Number of flowers in year of sowing	90	**103**
4	DATEFLOW	Date of flowering	91	**105**
5	HGHT PLT	Height of plant	99	**113**
6	WIDTHPLT	Width of plant	97	**111**
7	LEAFMARK	Frequency of plants with marked leaves	90	**103**
8	LF LGTH	Leaf length	92	**105**
9	LF WIDTH	Leaf width	91	**104**
10	PETTHICK	Petiole thickness	90	**103**
11	STOTHCK	Stolon thickness	90	**103**
12	NOHDEE30	Number of heads at ear emergence + 30 days	89	**102**
13	PET.LGTH	Petiole length	97	**111**
14	PED.LGTH	Peduncle length	93	**106**
20	%CYANOGS	Percentage with cyanogenesis	87	99

b) 2002 planted trial

	Trial 12 Clover
No Varieties	104
Efficiency Factor of the design	0.8866

Char	Char name	Character description	Efficiency*	Ratio
1	FLWRYOS	Number of flowers in year of sowing	92	**110**
42	COL SPR	Colour in spring	88	**107**

* %Efficiency is $100 \times \left(\frac{\text{variance of a variety mean from a CB analysis}}{\text{variance of a variety mean from an ICB analysis}} \right)$

where “variance of a variety mean” is derived from the 5% LSD’s output by the DUST CB and ICB analyses (ANAL9 and INCB9 respectively).

[End of document]