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EFFICIENCY OF INCOMPLETE BLOCK DESIGNS IN WINTER RAPE, SPRING RAPE AND YELLOW MUSTARD

Document prepared by experts from Denmark

Introduction

Spring Rape, Winter Rape and Yellow Mustard are some of the major crops for DUS-testing in Denmark, i.e. there are many candidate and reference varieties grown each year. At the same time some difficulties have been encountered in the establishment of distinctness of new candidates. Since spring 1997 the DUS trials with those crops have been laid out as resolvable incomplete block designs. Previous calculations using rape trials from Denmark and United Kingdom with complete blocks have shown that there could be some benefit from using incomplete blocks in rape trials (Kristensen and Jensen, 1998).

The present paper is an updated version of TWC/17/8 and describes the efficiency of three Danish trials with incomplete blocks in 1999 and some further comparisons of the efficiencies from applying COY-D to data from trials which are laid out as incomplete block designs.

Data

Results from 3 trials (1997, 1998 and 1999) with Spring Rape, 3 trials (1997, 1998 and 1999) with Yellow Mustard and 2 trials with Winter Rape (1998 and 1999) have been used. All trials were laid out as α-designs with 3 replicates. The actual dimensions of the designs used are shown in Table 1.

Table 1. Design parameters

Crop	Year	Number of			
		Entries	Plots	Reps.	Plots/block
Winter Rape	98	285	855	3	9-10
	99	336	1008	3	9-10
Spring Rape	97	114	342	3	9-10
	98	131	393	3	11-12
	99	142	426	3	11-12
Yellow Mustard	97	55	165	3	11
	98	66	198	3	11
	99	71	213	3	7-8

All UPOV characters that were based on field assessments and for which it could be assumed that the data could be analysed by linear mixed models were used. A list of those characters is given in Table 2. Twenty plants were planned to be recorded in most plots. However, a fewer number of plants per plot were recorded in some characters with reference varieties in 1999. Because of loss of plants, a few records were missing in some of the plots, and - for some of the recorded characters - some plots were not recorded at all (see Table 2).

Table 2. List of characters and number of recorded plots for each trial

Character identification	Character name	Number of recorded plots in trial							
		WR 98	WR 99	SR 97	SR 98	SR 99	YM 97	YM 98	YM 99
UPOV 6	Leaf: Number of lobes	822	1008	309	367	423	165	198	213
UPOV 8	Leaf: Length	822	1008	309	366	381	165	198	212
UPOV 9	Leaf: Width	822	1008	309	367	423	165	198	213
UPOV 10	Leaf: Length of petiole	822	1006	309	367	412	165	198	213
UPOV 13	Flower: Length of petals	818	1006	309	368	410	165	198	213
UPOV 14	Flower: Width of petals	818	1005	309	368	410	165	198	213
UPOV 16	Plant: Height (at full flowering)	822	1005	309	369	405	165	193	213
UPOV 17	Plant: Total length incl. side branches	821	1008	309	368	409	165	198	213
UPOV 18	Siliqua: Length	821	996	309	368	404	165	198	213
UPOV 19	Siliqua: Length of beak	821	995	309	368	404	165	198	213
UPOV 20	Siliqua: Length of peduncle	821	996	309	368	404	165	198	213

Method

The data from each trial were first analysed by three models: A, B, and C, using the same method as applied in TWC/17/8. The methods were A: the model for a randomised block design; B: the model for an incomplete block design assuming that the block effects are fixed and C: the model for an incomplete block design assuming that the block effects are random. All models were general linear models or general linear mixed models (see e.g. Searle, 1971 and Searle et al., 1992) and are described in detail in TWC/17/8. LSD values were also calculated in the same way as in TWC/17/8.

Each of the three models were used to calculate an estimate of the variety effect (done separately for each combination of crop, characteristic and year). The COY-D analysis was carried out for each crop and character on the varieties, which were present in all years (two for Winter Rape and three for Spring Rape and Yellow Mustard). Based on that analysis all pairwise comparisons between the varieties were performed and the number of pairs, which were significant different, were recorded for each of the three models.

Results

The effect of using incomplete blocks varied from character to character and from crop to crop (Table 3). The recordings of height (character no.16 and 17) and leaf length (character no 8) seemed to be the only ones where there always were a significant effect of incomplete blocks (tested in model B). For Spring Rape 1999 most characters showed a significant effect of incomplete blocks - as in 1997 (Kristensen, 1999). On average 61% of the trial/character combinations in 1999 showed significant effects of incomplete blocks at the 5% level of significance.

Table 3. Test of significance for effect of incomplete blocks. Values are percent probability of accepting the hypothesis that there are no fixed block effects.

Trial	UPOV Character number										
	6	8	9	10	13	14	16	17	18	19	20
Winter Rape 1999	25.2	0.0	0.0	0.0	0.0	1.4	0.0	0.0	10.5	0.0	0.5
Spring Rape 1999	47.4	0.0	0.0	0.3	22.1	1.9	0.0	0.0	38.5	32.5	48.1
Yellow Mustard 1999	28.9	1.4	11.9	19.1	31.7	40.7	0.0	0.0	0.6	1.2	21.9

The estimated variance components are shown in Table 4. The Table shows that for many cases the variance component for incomplete blocks is of the same magnitude as the variance component for replicates, which is in agreement with the results obtained for previous years (Kristensen, 1999). The variance components for plots had - as in previous years - in most cases the largest contribution to the total variance (when reported on plot level). In all cases the variance component for between plots were larger than the variance within plots. This indicates that most of the residual variance were caused by plot to plot variation and not by plant to plant variation. In some characters the variance within plots were considerably smaller than the variance between plots – e.g. for character 16 the contribution from between plots was between 38 and 69 times larger than the contribution from within plots.

Table 4. Estimated variance components in Spring Rape, Winter Rape and Yellow Mustard in 1999 based on the model with random block effects (model C)

Year and component	UPOV Character number										
	6	8	9	10	13	14	16	17	18	19	20
WR Replicate	.0035	79.8	29.6	.0006	.0026	.0663	5.9	5.2	.06	.0489	.155
WR Incompl.Blocks	.0023	80.5	12.6	.0015	.0545	.0152	19.3	21.5	.28	.0750	.162
WR Plots	.1850	313.8	55.0	.0078	.2858	.2347	22.9	26.6	6.57	.4495	1.745
WR Plants/20	.0336	9.2	4.1	.0004	.0327	.0271	0.6	3.9	2.28	.2692	.525
WR Total	.2244	483.3	101.3	.0102	.3756	.3433	48.7	57.2	9.20	.8425	2.588
SR Replicates	.0114	655	97.1	.0116	.1288	.1332	9.0	3.9	.01	.0192	.000
SR Incompl. Blocks	.0000	196	28.4	.0031	.0149	.0198	13.1	21.0	.02	.0064	.000
SR Plots	.4371	835	100.8	.0237	.4764	.2105	34.3	30.9	4.74	.2747	.925
SR Plants/20	.0523	17	5.9	.0013	.0346	.0202	0.5	0.9	1.54	.1124	.400
SR Total	.4752	1703	232.2	.0397	.6548	.3837	56.9	56.7	6.28	.4127	1.325
YM Replicates	.0359	83.0	10.7	.0039	.0023	.0066	17.1	7.17	.00	.00	.003
YM Incompl.blocks	.0056	30.8	7.37	.0005	.0077	.0019	25.9	28.6	.23	.0920	.021
YM Plots	.1252	176.3	89.1	.0084	.2620	.1004	22.8	69.0	.72	.3126	.210
YM Plants/20	.0466	7.7	5.4	.0006	.0506	.0245	0.5	1.4	.56	.2721	.169
YM Total	.2132	297.8	112.5	.0133	.3226	.1335	66.3	106.1	1.51	.6766	.403

The results from the COY-D analysis are reported as LSD-values for comparing two varieties. The LSD-values are shown in Table 5 and the values show that estimates based on model A (Complete block design) or B (incomplete block design with fixed block effects) only in few cases (5 or 2 out of 33) cases yields the smallest LSD value (using plenty of

decimals). In the remaining 26 cases model C (incomplete block design with random block effects) yield the smallest LSD value. In most cases the difference is small.

Table 5. LSD values from COY-D analysis based on each of the 3 models used for calculating the variety effect in a single trial.

Crop and method	UPOV Character number										
	6	8	9	10	13	14	16	17	18	19	20
Winter Rape A	.962	37.4	14.1	.196	1.02	.861	19.2	12.7	6.3	1.74	2.45
Winter Rape B	.987	38.4	14.0	.202	1.06	.862	18.2	11.5	6.4	1.82	2.54
Winter Rape C	.951	36.7	13.6	.194	1.01	.842	18.3	11.5	6.3	1.74	2.44
Spring Rape A	.837	39.4	14.7	.235	.84	.677	12.2	9.7	5.9	1.20	2.07
Spring Rape B	.873	37.9	14.0	.230	.90	.710	12.2	9.6	5.2	1.16	2.02
Spring Rape C	.838	37.6	13.8	.228	.85	.679	12.0	9.3	5.1	1.15	1.99
Yellow Mustard A	.519	20.6	10.0	.120	.99	.590	13.4	15.4	2.16	1.52	1.14
Yellow Mustard B	.525	20.9	10.0	.124	.92	.604	12.3	12.8	2.10	1.50	1.22
Yellow Mustard C	.513	20.4	9.8	.117	.88	.589	12.3	13.1	2.07	1.48	1.14

In order to examine how large the effect would be on the number of distinct pairs of varieties, all varieties, which were present in all years (2 years for Winter Rape and 3 years for Spring Rape and Yellow Mustard) were tested pairwise. The total number of varieties present in all years were 221, 77 and 51 varieties for Winter Rape, Spring Rape and Yellow Mustard, respectively. This means that the total number of examined pairs of varieties are 24310, 2926 and 1275 for Winter Rape, Spring Rape and Yellow Mustard, respectively. For the three crops the 11 characteristics tested were able to separate between 91.0% and 98.5% of the total number of pairs of varieties. The differences between the three different methods are relatively small - about .5% for Oil Seed Rape and about 1.5 % for Yellow Mustard. If a best method has to be pointed out it seem to be the method based on model C (incomplete block design with random block effects).

Table 6. Number of separations if each charactristic is the first one to be used. The separations are based on a COY-D analysis using estimates from the three models A, B and C.

Crop and method	UPOV Character number											
	6	8	9	10	13	14	16	17	18	19	20	All
Winter Rape A	6376	3849	2785	3583	9977	8991	4183	8422	10697	10645	12633	22539
Winter Rape B	6300	3642	2863	3273	9463	8643	4566	9392	10723	10066	12463	22479
Winter Rape C	6500	3881	2910	3591	9978	9031	4529	9385	10740	10596	12708	22610
Spring Rape A	1568	429	333	852	1715	1328	1356	1461	1298	1469	1498	2877
Spring Rape B	1522	437	336	849	1652	1252	1340	1433	1336	1504	1484	2869
Spring Rape C	1566	475	357	880	1705	1324	1356	1469	1342	1509	1534	2881
Yellow Mustard A	302	121	216	153	342	263	351	435	625	624	559	1160
Yellow Mustard B	315	82	235	104	308	235	382	544	644	632	519	1181
Yellow Mustard C	319	114	232	145	343	232	386	534	648	637	553	1179

Looking on the individual characteristics the largest effects (relative) on the number of separations are found for character 16 and 17 in Yellow Mustard. Here the number of separated pairs are increased by 10% to 22% when using estimates based on model C in stead of estimates based on model A.

Discussions and Conclusions

Previous calculations (Kristensen and Jensen, 1998) showed that incomplete blocks in most cases would be expected to improve the individual trial results. The analyses of data from incomplete trials in 1997 and 1998 presented last year (Kristensen, 1999) show that the incomplete block in 52% of the character/trial combinations had fixed block effects that were significant at the 5% level of significance. A similar result is found here for 1999.

The calculations based on Winter Rape, Spring Rape and Yellow Mustard show that the use of incomplete blocks for most characters yielded lower COY-D LSD values than complete blocks. Only in a few cases did the COY-D based on randomised complete blocks yield slightly better results than COY-D based on incomplete blocks.

The results indicates that the use of incomplete blocks yields better separations than complete blocks for most characters (using COY-D) although the benefit are generally small.

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