Experiences with incomplete block designs in Denmark

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- Introduction
  - Official variety testing
  - Heterogeneity of fields
- Used incomplete block designs
  - Types of trials
  - Types of designs
  - Layout in the field
  - No. of varieties
- Efficiency of the designs
  - Analyses
  - Relative efficiencies
- Discussion
  - Benefits
  - Drawbacks

Introduction

- Official variety testing
  - Two types of trials in Denmark
    - DUS trials (one trial per crop per year)
      - On one experimental station
    - Performance trials (4-6 trials per crop per year)
      - On experimental stations and private farms
  - Increasing number of varieties to be tested
  - The number of varieties in the trials cannot be determined by the experimenter
- Other trials for different types of research

Introduction

- Heterogeneity of fields
  - Size of experiment
    - Plot size most typical 1.5 m by 10-12 m
    - Size of complete blocks e.g. 150 m by 15 m or 75 m by 30 m or 50 m by 45 m (100 varieties)
  - Previous experiments on the land (crop rotation)
  - Soil heterogeneity
  - Heterogeneous application of e.g. fertiliser

Used incomplete block designs

- Types of trials
  - Distinctness Uniformity and Stability trials
    - Winter Rape, Spring Rape, Yellow Mustard, Sugar Beets, Winter Wheat, Spring Wheat, Winter Barley, Spring Barley, Oat, Grassland Crops
  - Performance trials
    - Winter Rape, Spring Rape, Yellow Mustard, Sugar Beets, Winter Wheat, Spring Wheat, Winter Barley, Spring Barley, Oat, Grassland Crops, Rye, Triticale, Maize and Potatoes
  - BAR-OF (Barley for organic farming)
    - Spring Barley

Used incomplete block designs

- Types of designs
  - α-designs
  - Lattice designs
  - Row-column designs based on α-designs
  - α-designs in split-plots
  - Ad. hoc. designs in a few cases

Used incomplete block designs

- Lay out in the field (principles)
  - Number of plots per incomplete block usually slightly less than $v^{0.5}$
  - Incomplete blocks should cover only one row of plots in the field
  - It should be possible to stop harvesting (and other operations in the field) at the border between two complete replicates

Used incomplete block designs

- Number of varieties in some crops in spring 2003
  - Spring barley: 101
  - Peas: 34
  - Maize: 74
- Since 1979 the number of varieties in the incomplete block designs has ranged from about 12 and up to more than 300

Used incomplete block designs

- Example 1 (α-design)
  - 119 varieties
  - 2 complete replicates
  - 15 incompletes blocks per replicate
  - 8 (7) plots per incomplete block
  - Laid out in 4 rows of plots with up to 63 plots in each

30		77	102	63	24	32	19
105		62	41	9	95	51	48
4		12	80	61	108	13	116
51		26	7	117	106	111	45
32		78	107	53	72	14	16
94		31	88	14	64	24	118
115		69	98	26	88	91	1
101	59	76	29	109	38	89	71
91	68	50	100	92	37	74	97
98	81	108	115	69	79	35	8
90	50	119	83	42	17	34	3
65	96	43	53	44	16	93	28
1	58	94	22	86	78	20	46
3	114	5	36	7	119	17	63
52	76	21	49	110	60	67	109
43	15	54	27	13	8	112	30
18	33	84	25	35	49	38	2
67	41	81	106	5	77	92	55
97	113	52	103	31	34	86	114
2	22	9	70	85	28	101	73
116	56	33	105	83	80	72	87
75	70	95	59	102	21	37	42
57	118	99	18	40	104	57	65
39	54	60	6	48	103	15	4
107	66	56	47	55	12	40	10
89	19	79	117	73	36		90
47	100	82	85	84	74		61
82	10	44	23	11	87		113
62	6	66	68	112	45		104
71	93	11	75	23	25		110
27	111	58	64	29	99		96
63	24	32	19	46	20		39

Used incomplete block designs

- Example 2 (Row column based on α-design)
  - 123 varieties
  - 3 complete replicates
  - 16 incompletes blocks per replicate
  - 8 (7 + ’guards’) plots per incomplete block
  - Laid out as row-column design with 24 rows of 16 plots

31	116	60	101	38	109	21	81	36	28	108	97	11	62	89	55
56	63	115	47	59	93	29	121	104	61	39	79	103	75	90	51
1	15	65	82	35	91	110	100	71	84	42	74	18	123	.	12
17	14	50	24	67	87	57	102	37	99	72	23	112	118	86	119
30	107	34	44	6	16	19	92	94	83	26	106	46	.	48	52
120	49	69	88	4	25	10	27	53	70	64	96	78	76	45	58
68	95	117	7	111	77	32	80	41	20	5	40	98	43	54	13
.	73	66	85	105	114	22	2	33	8	.	.	3	122	113	9
25	13	88	28	16	93	46	11	17	22	77	110	74	121	2	102
101	73	37	122	12	27	39	112	18	7	56	60	49	48	106	5
95	41	66	85	55	62	107	69	92	100	63	57	42	50	51	64
87	47	.	6	120	90	.	78	123	20	54	36	.	113	119	89
79	71	97	8	38	4	98	24	58	86	1	83	94	75	32	114
30	91	118	19	68	59	72	104	80	33	81	76	15	45	109	.
10	117	23	44	82	29	9	26	108	3	99	96	115	84	40	21
103	53	.	14	105	70	31	43	52	111	35	67	65	34	61	116
72	14	12	107	26	79	36	96	104	13	110	62	114	.	7	53
54	70	2	95	28	38	61	118	15	29	10	122	37	42	.	94
9	85	59	4	120	5	92	91	77	24	56	44	89	31	102	65
27	76	66	32	20	81	75	87	101	34	3	121	35	84	16	50
82	100	11	17	86	30	43	113	48	78	97	80	103	115	69	73
111	58	33	68	55	21	51	23	1	47	88	.	112	.	106	46
52	57	74	19	90	63	108	49	22	116	119	18	45	8	98	117
105	93	6	.	64	25	67	60	40	99	39	83	109	41	123	71

Analyses of α-designs

(1) $Y_{vb} = \mu + \alpha_v + \gamma_b + E_{vb}$

(2) $Y_{vrb} = \mu + \alpha_v + \beta_r + \gamma_{rb} + E_{vrb}$ Blocks within reps

(3) $Y_{vrb} = \mu + \alpha_v + \beta_r + C_{rb} + E_{vrb}$ Blocks effects random

E_{vb}, E_{vrb} and C_{rb} asumed independent and normal distributed with constant varians, σ_E^2 og σ_C^2

Analyses of Row column based on α-designs

(1) $Y_{vsc} = \mu + \alpha_v + \gamma_s + \delta_c + E_{vsc}$

(2) $Y_{vrsc} = \mu + \alpha_v + \beta_r + \gamma_{rs} + \delta_{rc} + E_{vrsc}$ s and c within replicate

(3) $Y_{vrb} = \mu + \alpha_v + \beta_r + C_{rs} + D_{rc} + E_{vrsc}$ s and c effects random

E_{vsc}, E_{vrsc}, C_{rs} and D_{rc} assumed independent and normal distributed with constant varians, σ_E^2, σ_C^2 and σ_{D}^2

Relative efficiencies

- Sugar beets
  - 13 to 30 varieties
  - 4 to 6 plots per block
    - Root dry matter 1.4 1.0-2.0
    - Top dry matter 1.8 1.0-3.1
    - Sugar weight 1.4 1.0-2.1

Relative efficiencies

- Barley
  - 100 to 123 varieties
  - 8 to 10 plots per block

• Yield (grain)	1.4	1.0-2.5
• Relative dry matter in grains	1.4	1.0-1.7
• RVI	1.9	1.4-2.4
• Weed coverage	1.4	1.0-2.0
• Weed counted	1.1	1.0-1.2
• Disease coverage	1.0	1.0-1.1

Discussion

- Benefits
  - Increased prediction of parameters for variables that seem dependent on soil fertility?
  - More equal variances from trial to trial, as the increase in prediction was greatest in trials with high variability
  - Possible to decrease number of replicates
  - More easy to layout reasonable in field

Discussion

- Drawbacks
  - More complicated design layout
  - Slightly more sensitive to missing observations
  - More complicated analysis
  - No simple connection between registrations and published results