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
  – $\alpha$-designs
  – Lattice designs
  – Row-column designs based on $\alpha$-designs
  – $\alpha$-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
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Used incomplete block designs

• Example 2 (Row column based on $\alpha$-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
Analyses of $\alpha$-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 $C_{rb}$ assumed independent and normal distributed with constant variances, $\sigma^2_E$ og $\sigma^2_C$
Analyses of Row column based on $\alpha$-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 variances, $\sigma_E^2$, $\sigma_C^2$ and $\sigma_D^2$
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