Slide 1

Hybrid cultivars

Advantages & disadvantages

Clemens van de Wiel, Jan Schaart & Bert Lotz

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Hybrid cultivars

- Hybrid (F1) cultivars standard in many crops
  - Arable: maize, sugar beet, oilseed rape
  - Vegetables: tomato, cabbage, carrot, onion

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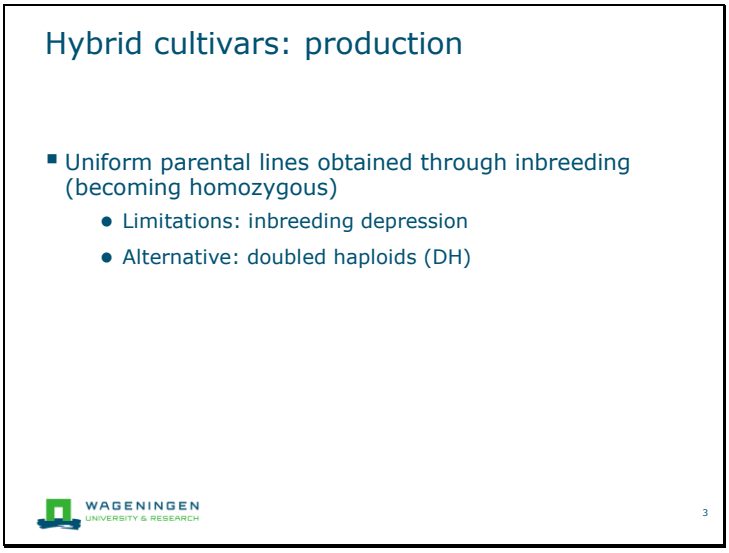

Haploid plants can be directly obtained from cultures of anthers or ovules, provided a successful protocol has been developed for the crop. After doubling of chromosomes, diploid plants are re-obtained that are homozygous. In this way, homozygous lines can be produced much faster than through inbreeding (selfing).

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Hybrid cultivars: production

- For each round of F1 hybrid seed production, two specific parental lines are crossed
  - Heterosis ("hybrid vigour"): hybrid growth significantly stronger than the (best) parental lines
  - Heterozygous but uniform cultivar

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Hybrid cultivars: production conditions

- Efficient outcrossing system
  - Male sterility MS in maternal line to prevent selfing
    - Otherwise labour-intensive methods (relatively simple mechanical removal of male inflorescences in maize, hand pollination in e.g. cotton)
    - Most optimal: cytoplasmic MS (CMS), e.g. Ogura in oilseed rape (canola) & Brassica vegetables (cabbage, broccoli etc.)
    - Multiplication of MS line using fertility-restoring genetic factors (in nuclear DNA with CMS)
    - Also GM systems developed, incl. ones producing F1 hybrids without MS transgene

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Hybrid cultivars: production conditions

- Efficient outcrossing system (continued)
  - Optimal pollen transfer
    - Problematic in selfing crops with more or less cleistogamous flowers (stigma and anthers hardly protruding, wind pollinators such as wheat) or flowers less attractive to insects (lettuce)
    - Field conformations optimized for seed production while preventing foreign pollinations (from other plants than desired paternal line)

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Hybrid cultivars: production conditions

- Heterosis
  - Complex: various mechanisms (combinations)
  - Heterozygosity, usually performing best with genetically strongly different parental lines (large genetic distance)
    - Combinability of parental lines tested empirically
    - Arrangement into heterotic groups of lines that optimally combine with lines from other heterotic groups

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Hybrid cultivars: production conditions

- Heterosis: possible mechanisms
  - Dominance: combining large number of dominant alleles
    - Recessive alleles responsible for inbreeding depession
  - (Pseudo)overdominance: heterozygous combinations of alleles on a locus performing better than homozygous versions
  - Epistasis: effects from interactions between loci
  - Combinations of mechanisms
    - May vary per crop

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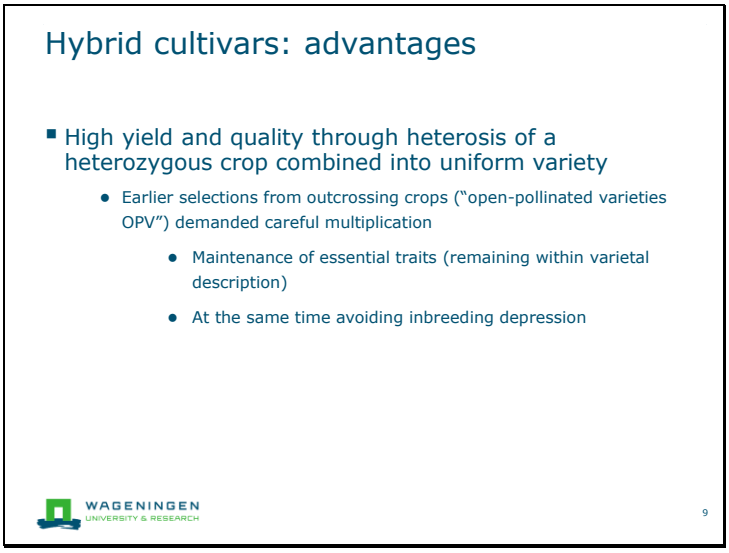

Crow (1998) Genetics 148:923: 1920-1965 considerable yield increases related to two generations of breeding to optimize production of F1 hybrids: first two crosses were necessary ("double cross"), subsequently parental lines were optimized to the extent that they could be directly used for hybrid production ("single cross").

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Hybrid cultivars: advantages

- Inherent breeder's protection
  - At multiplication, optimal allele combinations segregate
    - Farm-saved seeds accompanied by quality loss
  - Breeding incentive by higher revenues: each cultivation demands new hybrid seed purchase
    - Maize for instance more attractive than wheat with frequent use of farm-saved seeds
    - Thus also ongoing investments in hybrid wheat development

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Hybrid cultivars: disadvantages

- Inherent breeder's protection
  - At multiplication, optimal allele combinations segregate
    - Need of compensation of higher seed prizes by higher yields and/or quality to remain attractive to grower

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Hybrid cultivars: disadvantages

- More complex seed production (particularly compared to selfing crops)
  - Measures to prevent selfing of maternal line
  - Measures to prevent pollination by other than desired paternal line
    - Isolation distance up to 1 km with sugar beet
  - Risk of exclusive use of particular CMS in lack of genetic diversity
    - Maize T-cytoplasm turned out sensitive to new variant of fungus *Cochliobolus* (Southern corn leaf blight), leading to enormous production losses in US 1970

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Hybrid cultivars: disadvantages

- Not yet applicable to each crop
  - Lack of (C)MS or efficient outcrossing system
  - Wheat, soy, lettuce...
- Alternative: apomixis (seed set without fertilization)
  - Not yet applicable to each crop
  - No inherent breeder's protection

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Hybrid cultivars: discussion

- For instance, in organic sector hesitations towards hybrid cultivars
  - CMS often product from biotechnology (cell fusion), even though exempt from GM regulation (2001/18/EG)
    - E.g. Ogura CMS common in *Brassica* oilseed and vegetable crops
  - Socio-economic discussion comparable with GM:
    - Differences in market power between seed producer and grower (and between larger and smaller breeding companies, e.g. IPR on CMS)
    - Affects autonomy of small grower (family-owned farm)
    - On the other hand, more optimal seed quality

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