Potential for the use of new plant breeding methods for crop improvement in the Czech republic

Tomáš Moravec

September 13th, 2018

NBT in plant breeding:

Situation in specific crops:

- Flax, Pea (Agritec, Šumperk, IBP)
- Potatoes (PRI, Havl. Brod)
- Hops (HRI, Žatec)
- Cereals (CRI, Prague, IEB+CRH, Olomouc, etc)

General findings – opportunities vs. challenges

Conclusions

Acknowledgements

Flax

Linum usitatissimum, diploid (2n = 16, 18, 20, 26, 28, 30, 32, 36, 42, 72, 84)

- **both fiber and oil crop**
- **unique oil composition important for food and pharmaceutical industries as well as arts**
- **can be modified using floral dip !!! (ex vitro proces)**
- **TALEN modified oil composition (FAD2),**
- **dihaploid cultures technology available**

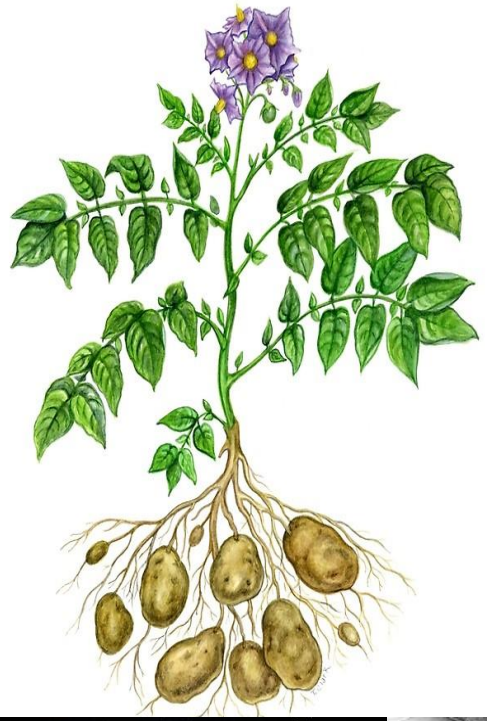
Peas

Pisum sativum, diploid (2n = 14)

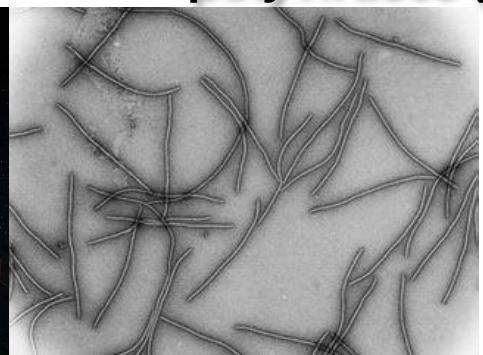
- **old genetic model (Mendel)**
- **while difficult to transform, technology available in Agritec,**
- **genomic sequence not complete yet**
- **unique fully genotyped and phenotyped genetic bank available**
- **CRISPR/Cas9 modification of seed protein composition,**
- **although important part of crop rotation for soil health , area very low, competes with imported GM-enhanced soybean**

Potatoes

Solanum tuberosum, tetraploid (4n = 48)



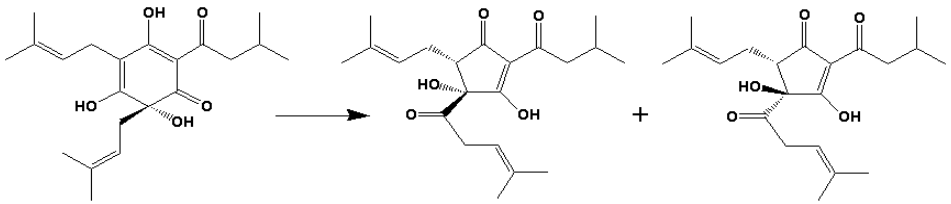
- **highly heterozygous genome**
- **conventional breeding programmes 10-15 years,**
- **interest in disease resistence (viruses, fungi) and starch composition traits**
- **cytoplasmic hybridisation (nonGMO technology) for *Phytophtora* resistance**
- **NBT carry potential for broad resistence to all potyviruses (PVY, PVA) using eIF4Es knockout**



Hops

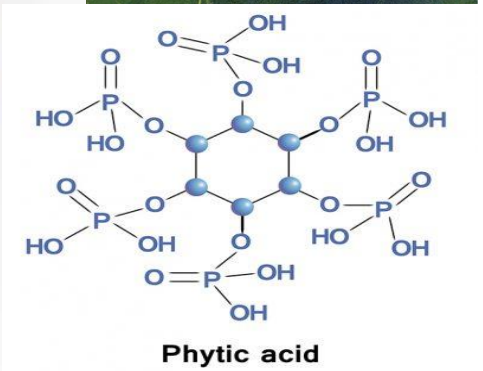
Humulus lupulus
dioecious (2n = 18 + sexual chromosomes XY)

- **Hop research institute – leader in hops genetics,**
- **genomic sequence available**
- **extremely complex crop and traits (quality comprises complex mixture o chemicals)**
- **very difficult crossing, low viability, backcrossing impossible**
- **although the regeneration protocols exist, they are very unpractical**
- **example of important crop that will probably not benefit much from current NBT, even if permitted by law**



Barley

Hordeum vulgare
diploid genome, 2n=14

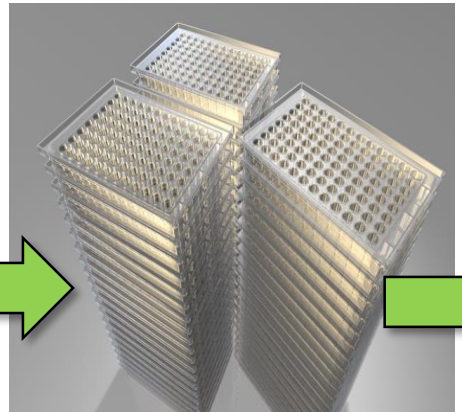


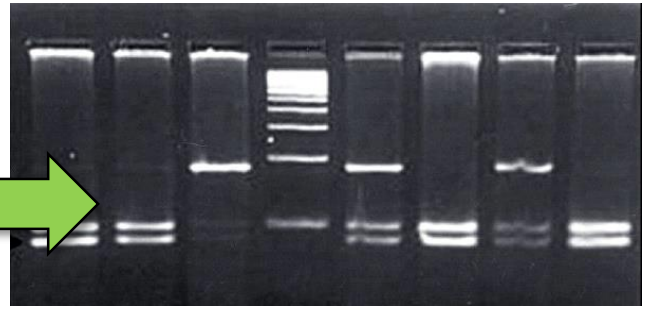
- **Dr. Ohnoutková – leader in phosphorus storage**
- **CRISPR lines with modified phytate content**
- **improved nutritional and environmental profile**
- **example of crop, that can greatly benefit from NBT introduction**

Wheat

Triticum durum, aestivum
tetraploid or hexaploid genome, 4n=28, 6n=42

- **Dr. Dolezel – leader in wheat genetics,**
- **complete genome released just recently (Aug 2018)**
- **Rapid cloning (NatBiotech, 2017) and CRISPR used mainly to identify important genes,**
- **project on CRISPR/Cas9 mutagenesis of genes regulating vernalisation**
- **Mutations in breeding material originate from public resources, tilling libraries**
- **NBT expensive, unclear licensing, GMO-status**





NBT- opportunities

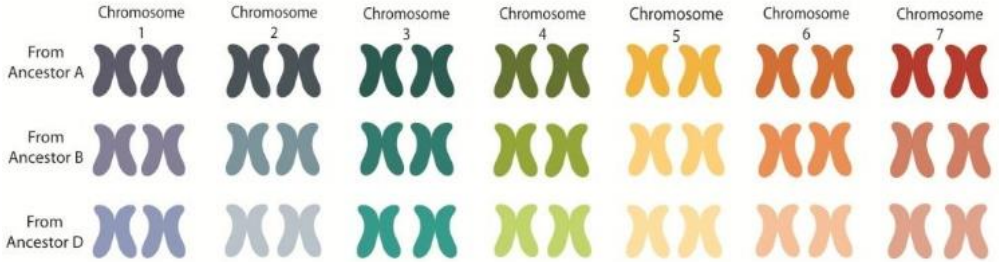
- Several academic, university and research institutions posses the know-how and equipment to use state-of-the art breeding techniques for crop improvement (know what and how)

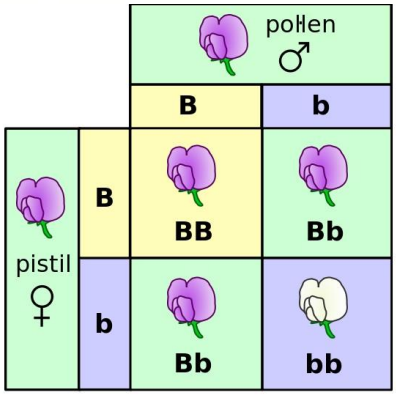
- Smaller breeders can access these technologies through cooperation or through out-sourcing (Application laboratory, CRH)

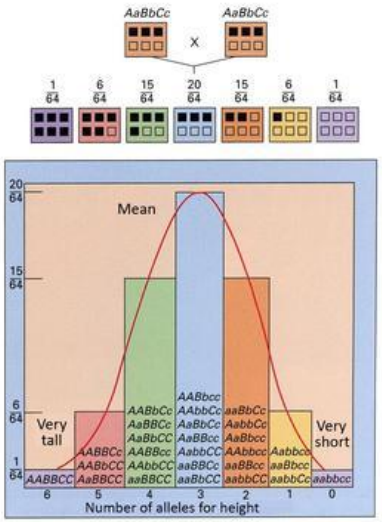
- Several crops have been gene edited for improved composition
- There is a potential to use NBT for improved disease resistance
- Use of NBT can save several years of development, and allows allele combinations impossible to get by conventional mutagenesis and/or hybridisation

NBT – technical challenges

- Crops typically have more complex genetics than model plants (polyploidy, heterozygosity, etc)
- Some crops are recalcitrant to transformation
- Basic TALEN/CRISPR gene editing typically confers recesive traits
- Multigenic resistance typically more durable
- Detailed knowledge of gene function is necessary

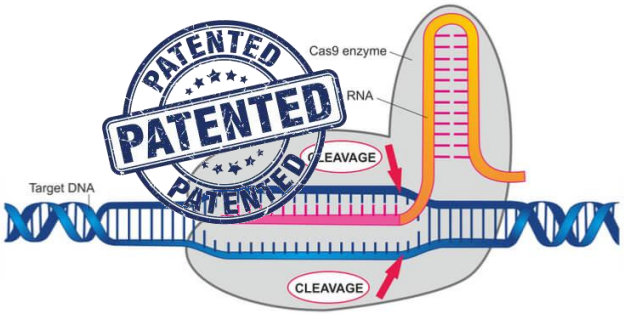






NBT – legal challenges

- CRISPR is patented technology, not clear licensing policy, difficult to obtain freedom to operate
- TALEN – relatively manageable licensing policy (Thermo-Fischer etc)
- generation of targeted mutations is rather costly, while TILLING of available libraries is inexpensive
- for long period the GMO status was not clear, the ECJ decission put the last nail in the coffin
- GMO status removes the NBT out of the reach of academia and SMEs



Conclusions:

- **Strong ties between both academic/ applied research and breeding sector**
- **There is sufficient know-how and expertise to use new breeding techniques**
- **While new techniques are favorite tool in academic research, their practical deployment is limited:**
  - **Some crops not suited for molecular improvement**
  - **Some traits not yet developed**
  - **Some traits polygenic**
  - **IP rights unclear or expensive**
  - **Restrictive legal framework**
- **Their major contribution currently will be in gaining knowledge about gene functions, the commercial traits will be developed using nonGMO methods**

Acknowledgements

Lidka Ohnoutková,
Jan Šafář

Marie Greplová
Jaroslava Domkářová

Josef Patzak

Miroslav Griga
Michaela Ludvikova

Vojtech Hudzieczek
Jana Chrpová

and others…..

Acknowledgements

MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY

The work was supported by the Ministry of Education, Youth and Sports of CR from European Regional Development Fund-Project "Centre for Experimental Plant Biology": No. CZ.02.1.01/0.0/0.0/16_019/0000738.