Advances in Plant Mutation Breeding

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Background: Agriculture challenges

World agriculture sustainability is threated by an increasing human population, reduced availability of cultivated land and changing climate patterns. Among the breeding methods, conventional breeding shows limitations and transgenic breeding presents controversies. Thus plant mutation breeding is a major component in addressing these concerns in developing novel germplasm in a relatively short time. Plant mutation breeding has three major features: 1) the choice of and the treatment with mutagens, 2) the development of suitable mutant populations and 3) the selection of desired mutants. It is these three steps that form the basis of this study in developing 1) alternative physical mutagens (non-radioactive); 2) new methods for population development; and 3) new phenotypic screening methods for desired mutants in a range of crop plants.

Alternative non-radioactive physical mutagens

Adaption of the RS-2400 X-ray irradiator to plant mutation breeding

Fig 1. Gamma irradiator versus X-ray irradiator

Table: Example mutant spectrum of Gamma ray versus X-ray in sorghum

Phenotype (%)	Gamma ray (Gy)		X-ray (Gy)	
	200	400	200	400
Normal	63.2	40.9	74.5	63.2
Pale green	5.2	2.3	1.5	0.0
Necrotic leaf	1.7	0.0	0.1	5.3
Mottled leaf	1.1	2.3	0.7	0.0
Dwarf	0.9	6.8	2.9	5.3
Tall plant	1.1	2.3	0.5	5.3
Thin leaf	17.0	29.5	12.7	21.1
Broad leaf	1.1	0.0	1.5	5.3
Early flowering	0.2	2.3	1.6	0.0

X-rays versus Gamma ray irradiation

- Efficient mutagenesis in plant material
- A similar range of mutants
- Are a valid alternative to gamma rays
- Can be widely used once methods are optimized

Development of mutant populations

In vitro methods for mutation induction in potato (*Solanum tuberosum* L.)

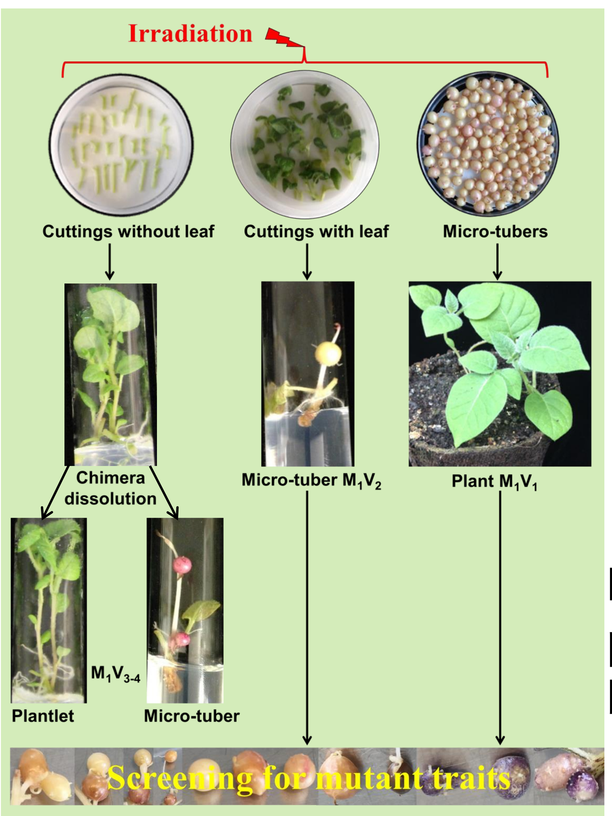

Fig 2. Scheme for potato mutation breeding

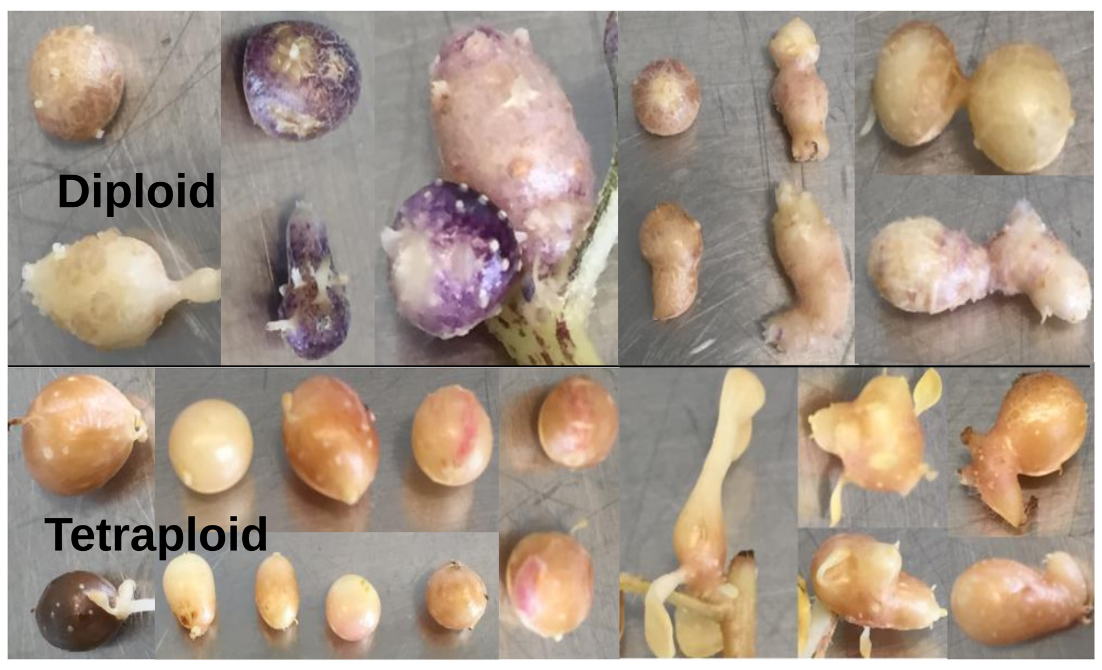

Fig 3. Putative color and shape mutants of potato

- Good target for mutation induction
- Can be produced all year round
- Can be stored (over 6 months)
- Can be used in early screening
- Can enhance mutant frequency

➢**Promising mutants for Potato Cyst Nematodes and Blight resistance have been identified.**

Pre-screening methods for mutant detection (salinity in crop production *e.g.* rice)

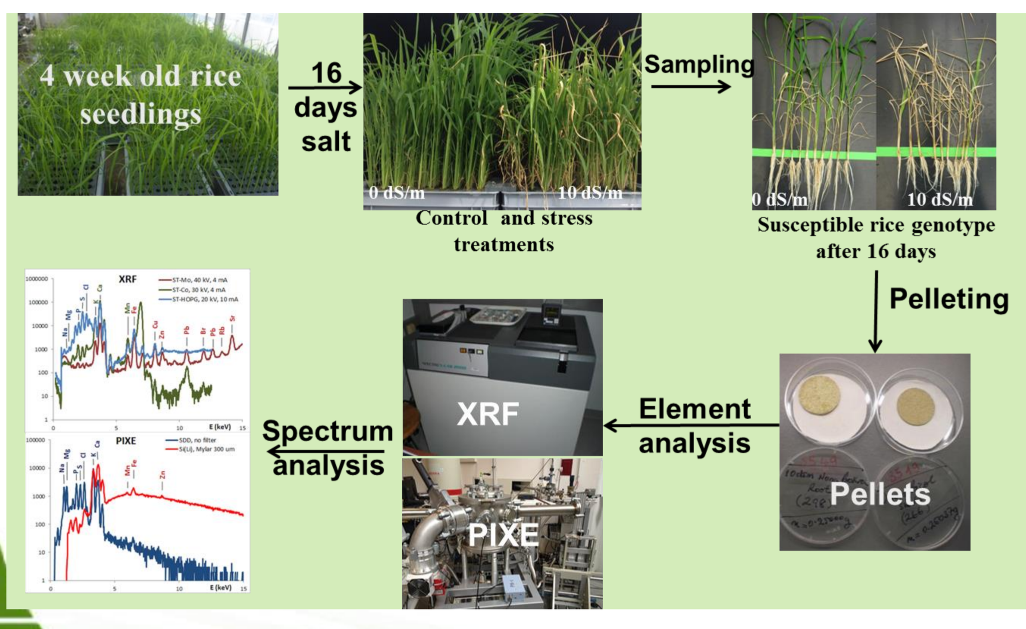

Fig 4. Scheme for salt screening in rice

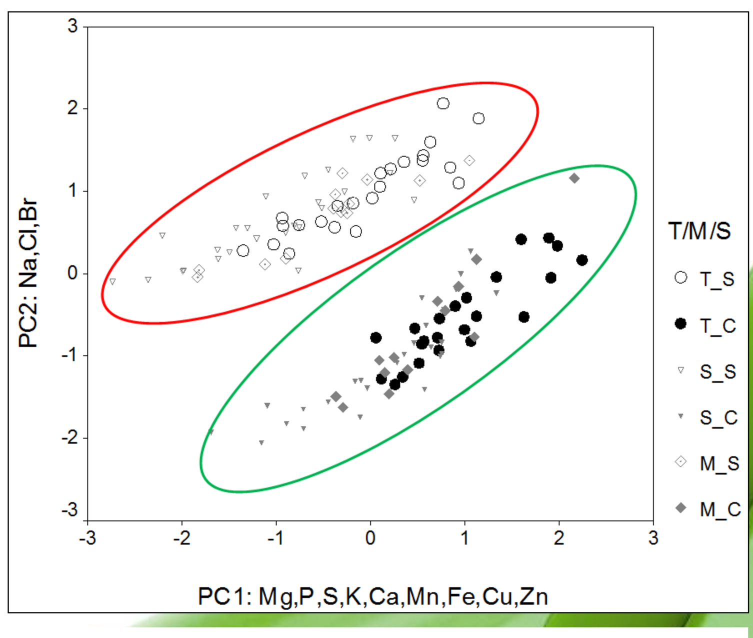

Fig 5. Clustering of rice genotypes according to the treatment and salt tolerance (S - susceptible, M -Moderate, T- tolerant genotypes) and to the group C- Control, S – Salt treated) base on principal component analysis (PCA).

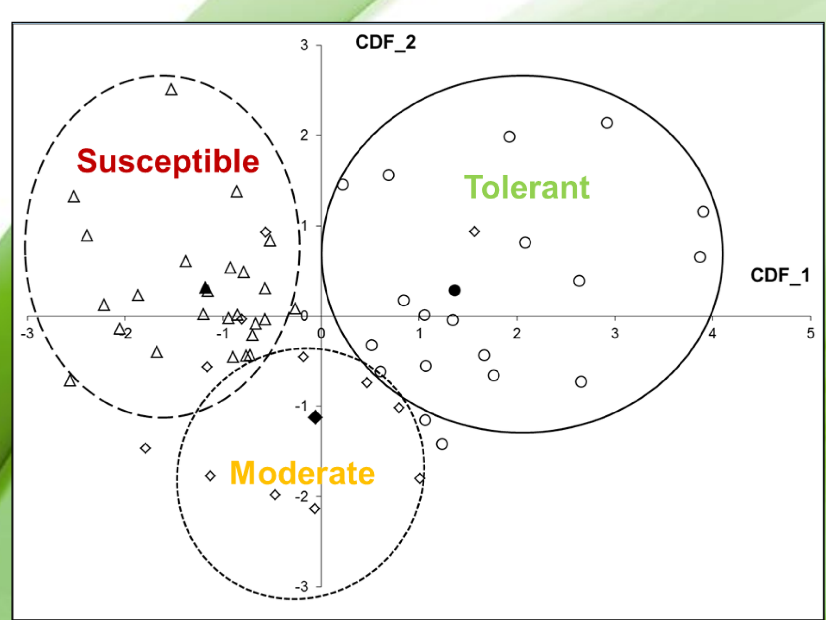

Fig 6. Clustering of rice genotypes with known salt tolerance into the three salt tolerant categories (Tolerant, moderate and susceptible) base on conical discrimination analysis (CDA).

- Growth performance was linked to salt tolerance
- PCA could distinguish treatments and genotypes with respect to tolerance to salinity
- CDA allowed the three classes (salt tolerant, moderate tolerant and susceptible) to be separated

Overall summary

- ➢ Efficacy of X-ray as an alternative to gamma ray in plant mutagenesis
- ➢ Micro-tubes are important plant materials for mutation induction in potato
- ➢ Salt tolerant rice genotypes can be selected under non-stress conditions
- ➢ Marker associations can be efficient in selecting lines for nutritional quality