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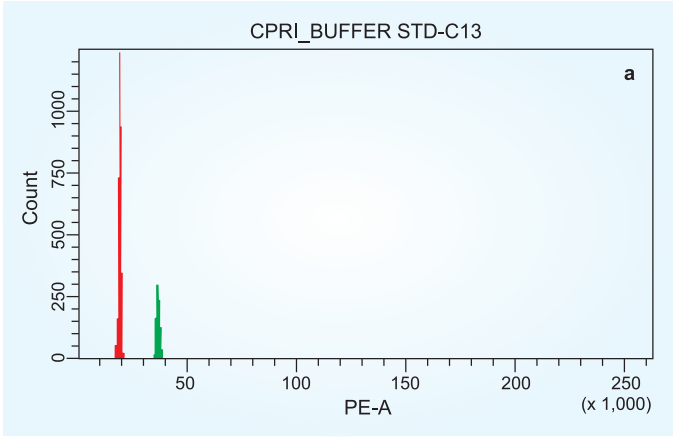
Reinventing potato breeding through true potato seed based technology

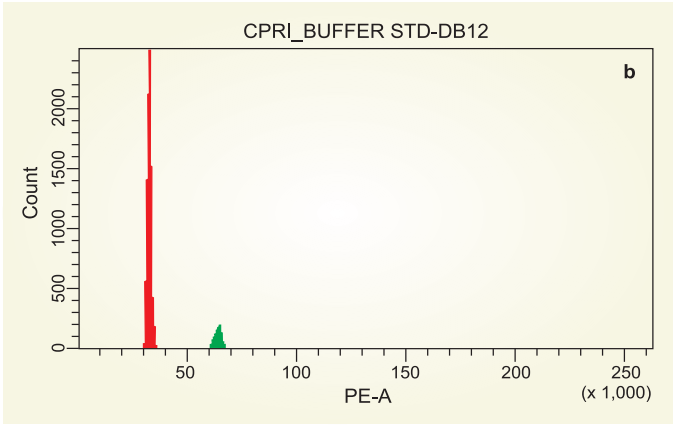
Potato is the major staple food in many countries of the world. It has a long history of cultivation in its area of origin i.e. Andean region of Peru. It is propagated through tubers to maintain the purity of cultivars due to high heterozygosity and polyploid genome. The cultivated potatoes are auto-tetraploid and self-compatible. But upon selfing they show high inbreeding depression due to high heterozygosity in parental lines and may be expression of lethal alleles on selfing. The homozygous lines therefore could not be developed in tetraploid potato and the varieties as well as advanced breeding material are maintained in the form of tubers only. Maintenance of varieties and other breeding lines through clonal propagation in the form of tubers lead to accumulation of pests and diseases particularly viruses, which keep on multiplying in each cycle of clonal propagation. This leads to diminution of varieties productivity and acceptance. Moreover, the potato breeding programme takes more than 12 years to develop a new variety and is based on clonal propagation of tubers. The seed of the variety is also multiplied clonally through tubers with a seed multiplication rate of approximately 1: 8 tubers per year. There are two approaches which have been envisioned at the global level for using TPS as the propagation material in potato.

POTATO propagation through diploid hybrid TPS is a completely new breeding method, developed in Netherland and is being adopted in all potato growing countries including India. The new diploid hybrid breeding technology works by sexual propagation. The method is based on identification, evaluation of diploid cultivated species and dihaploids of *Solanum tuberosum* for selection of desired clones with acceptable tuber and other plant traits. Diploid potatoes are naturally self-incompatible. The *sli* gene for inducing self-compatibility is introgressed in diploid clones and selfing is done for few generations to get homozygous diploid lines. The diploid homozygous inbred lines are evaluated for various tuber, plant and adaptation traits and potential lines are selected for hybrid combinations to accumulate desirables genes from both the parental lines in F1 hybrid. Development of homozygous diploid lines with desired traits is a step by step process which require many crossings and selection cycles. Thereafter, the hybrid combinations are tested to produce new hybrid offspring which share

Diploid accessions multiplication in glass-house

the best features of both parental lines. This sexual crossing of the two parent lines results in thousands of true potato seeds per plant instead of only a few potato tubers. So multiplication of a new variety can occur much faster. Since the offspring of a sexual cross is a pristine true seed, these are completely free of diseases and therefore make excellent seed material for potato growers around the world. These hybrid true potato seeds can be sown and grown into seedlings, and these seedlings will be transplanted into the field for commercial crop. The technology provides the opportunity to quickly develop new varieties to meet specific requirements. By improving the elite parent lines we can improve their offspring variety for the target trait more easily, quickly and in a targeted way. The genetic gains in potato breeding will be much higher using TPS based diploid hybrid breeding in potato.





Ploidy analysis through flow cytometry for confirmation of diploids a) Diploid b) Tetraploid

Diploid berries in self-compatible diploid lines

Self-compatible diploid *S. tuberosum* tubers

b) Variety specific TPS through meiotic genes editing

Another way to use TPS as propagating material is by fixing the heterozygosity. This involves the production of unreduced gametes (2n) and thereafter use of haploid inducer lines to get the normal parental type tetraploid plants without segregation. This can be done by deploying the CRISPR-Cas genome editing tools to disrupt the expression of major genes involved in meiosis so as to develop apomeiotic seeds. The process involves targeting of meiotic process in potato by modifying the 3 genes having role in recombination and segregation phases of cell division which leads to the production of unreduced gametes. The plants producing unreduced gametes will be hybridized with haploid inducer lines to get normal ploidy parental type true potato seeds. This novel hypothesis could result in fixation of heterozygosity in TPS production.

TPS propagation technology could revolutionize the potato cultivation, industry and research across the globe. The true potato seeds (TPS) i.e. botanical seed is never used in propagation of varieties which otherwise is easy to maintain, easy to transport, easy to store, amenable to genetic manipulations and is free from viruses, diseases and pests inoculums.

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