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Breeding Program in Potato (*Solanum tuberosum* L.)

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Potato (*Solanum tuberosum* L.) is world's major non-cereal food crop preceded by only rice, wheat and maize. It belongs to the family Solanaceae and the genus *Solanum*, which contains about 2000 species, out of which nearly 235 are tuber bearing. The commonly cultivated potato is a tetraploid and belongs to the species *Solanum tuberosum*, which includes two subspecies viz. ssp. *tuberosum* adapted to long days and ssp. *andigena* adapted to short days. The centre of origin of potato is known to be the Andes of southern Peru and northern Bolivia.

Potato breeding has been a cumbersome task due to inherent biological factors, cytoplasmic nuclear sterilities, tetrasomic inheritance and inbreeding depression. The conventional potato breeding programmes depend mainly on the identification of promising parental lines for making desired crosses, creation of genetic variability through crossing and subsequently selection of desirable recombinants for further evaluation and vegetative propagation. In India, varietal improvement for potato was beset with innumerable challenges. Introduced European varieties in the country were all long-day adapted, their multiplication in Indian led to progressive accumulation of viral diseases resulting in concomitant decrease in yield. Besides, limitations of tuber storage facilities and utilization in hot and humid Indian conditions were other bottlenecks. To breed potato varieties suitable for subtropical conditions of India, potato breeding programme was initiated in 1935 at the Potato Breeding Station (PBS), Shimla. However, a regular breeding programme was started in 1949 with the establishment of Central Potato Research Institute (CPRI) at Patna, Bihar.

Botany

Stem: Potato is a much branched, erect spreading herb, growing at 0.5 -1.5m height. The plants are erect when young and thus grow prostrate to the ground because of leaf form. The above ground shoots are called 'haulms'.

Leaves: Leaves are compound, pinnate, 10-20 cm long alternatively arranged.

Inflorescence: It is a monochasial cyme (cymose inflorescence developed in single system of branching). Flowers are white. Petals are white /cream in colour.

Stamens: Five in number (yellow to orange in colour). Anthers are erect and longer than the filaments with apical dehiscence.

Ovary: Ovary is superior, bicarpellary, style is simple and erect capitates. Stigma is capitate.

Fruit: Fruit is a berry with numerous small seeds. Potato fruit is also called as potato ball or Potato apple or Seed apple.

Floral biology

- Anthesis time and closing of flowers varies with varieties and species.
- Cool wet weather makes flowering more while hot weather depresses flowering.

- Most of the commercial potatoes have been proved to be either pollen sterile or to possess little pollen of low fertility.
- Diploid species have abundant pollen.
- A photoperiod of 14 -18 hours and night temperature of 15 to 20°C favours flower production.

Plant Morphology

Roots: Potato plant may develop from seed or tubers. Plants grown from seed form a slender tap root with lateral branches. Plants grown from tubers form adventitious roots at the base of each sprout and, later above the nodes of the underground part of each stem. Occasionally, roots may also grow on stolons. In comparison with other crop, the potato root system is weak. Therefore, good soil condition is necessary for potato growing.

Stolons: Morphologically, potato stolons are lateral stems which grow horizontally below ground from buds of the underground part of stems. stolon may eventually form tubers by enlargement of their terminal end.

Tubers: Morphologically, tubers are modified stems and constitute the main storage organs of the potato plant. The eye of the potato tuber morphologically corresponds to the nodes of stem. Sprouts grow from the buds in the eyes of a tuber. The colour of the sprout is a distinguishing varietal character.

Stem: Stem is generally solid, ribbed or smooth.

Leaves: Leaves are compound, pinnate, 10-20 cm long alternately arranged. Terminal leaflets are larger in most varieties and therefore the shoots lie prostrate to the ground.

Cytology

- Potato has basic chromosome number 12.
- From diploid to hexaploid species are available.
- Cultivated potato S. tuberosum is an autotetraploid (2n=48).
- About 75% species are diploid while about 15% species are tetraploids.
- Triploids and pentaploids are highly sterile and maintained by vegetative propagation.

Breeding Uniqueness

Propagated asexually

a) Transmission of diseases through tubers.

b) Easy maintenance and multiplication of elite material in original state through vegetative propagation.

c) Complex tetrasomic inheritance due to autotetraploidy.

d) Diverse source of germplasm including wild relatives for resistance to biotic and abiotic stresses.

Reducing sugar content: In the chip processing industry, light-coloured chips are preferred. Chips colour can be evaluated visually or by caolorimetric reflectance. The inheritance of chips colour is considered complex.

Glycoalkaloid content: Potato tubers have low levels of glycoalkaloids, comprising mainly solanine and chaconine. A concentration of 20 mg per 100 g fresh weight considered safe. If higher concentrations develop in the tuber, a bitter taste is noted, and at very high concentrations these compounds can be poisonous.

Potato Breeding Development in India

- In India, potato breeding programme was initiated in 1935 at the Potato Breeding Station, Shimla.
- Regular breeding programme was started in 1949 with the establishment of the Central Potato Research Institute (CPRI) at Patna, Bihar.

- Headquarter of the CPRI was later on shifted to Shimla (1956) in order to facilitate hybridization and maintenance of seed health.
- The major breakthrough in potato improvement programme came in 1963 with the development of "Seed Plot Technique", which made it possible to raise, evaluate, select and multiply breeding material under disease free conditions in plains.
- This led to the development of a system, wherein crossing was attempted in the hills and raising of seedling, evaluation and maintenance of segregating population was done in the plains.
- All varieties released by the CPRI carry the prefix 'KUFRI' as a memento to the place of hybridization.

Genetic Resources

Potato germplasm at CPRI
Ssp *andigena*: 872-from 7 countries Ssp *tuberosum:* 854- from 32 countries
Wild semiculture Ssp :250-from 4 countries

Breeding Methods

Introduction:

- The introduced European varieties were long day adapted.
- The multiplication of these varieties in Indian conditions was accompanied by progressive accumulation of degenerative viral diseases.
- Earlier varieties: Craigs defiance, Magnum bonum and Up-to-date.

Hybridization Technique:

- Potato naturally flowers under cool climate and long-day condition of more than 15 hrs light. Such conditions are available during long-summer days when potatoes are grown in hills. Hills are therefore, ideal for hybridization work.
- Potato flowers are hermaphrodite (bisexual) and therefore emasculation is done in selected female parents mostly in the evening.
- Flowers from selected fertile male parents are collected a day in advance, shade dried and pollens extracted next day in the morning in petri- dish or container

Hybridization and Selection:

In hybridization, crosses are made between selected parents. Hybridization can be between varieties (intervarietal) or between species (interspecific). Since yield and most of the desirable characters are polygenic in nature, the parents for hybridization are generally selected on the basis of their combining ability.

Being vegetatively propagated, breeders take advantage of selecting and multiplying genetically identical individuals in the succeeding generations.

Kufri Kundan - Selection from Ekishrozan × katahdin
Kufri Jyothi - Selection from A-3069 × A-2814

Back Cross method: Cultivated potato does not possess resistance to most of the diseases and pests. Resistance genes are mostly found scattered in wild and semi-cultivated species available in centre of origin and diversity in South America.

In this method, the hybridization is done between cultivated and wild or semi cultivated species with the aim of transferring specific characters like resistance to diseases and pests. It is followed by repeated back crossing, keeping cultivated type as recurrent parent. Selection is practiced in successive

back cross generation for the character to be retained from the wild species. However, transfer of the resistant genes from wild species into cultivated potato is a difficult task.

Heterosis: Heterosis is observed for earliness, tuber size and tuber weight. F1 seed production by hand emasculation and pollination after identification of good specific

combination. Pollen sterility is common. Inbreeding depression is more. Seed set is poor. Not exploited.

Polyploidy breeding:

- Potato is basically a polyploid.
- Haploids -Tetraploid × diploid.
- Different species are with different ploidy level. For resistance breeding, ploidy breeding is must.

Biotechnology

The application of biotechnology in potato breeding has been found useful in many ways. Potato was ideal material for application of biotechnological method such as anther culture, somatic hybridization, genetic information, in vitro, somaclonal variation selection and production of transgenic. Tissue culture technique is used for propagation of virus free plant material. It can generate somaclonal variation useful for selection.

- Protoplast fusion by somatic fusion of leaf mesophyll protoplasts has provided opportunity to transfer useful genes especially for disease and insect resistance from wild species and other diverse sources to cultivated potatoes.
- A protein nutrient rich transgenic potato has been devoloped by incorporating the protein synthesizer gene Am A1 (Storage Grain Protein Gene) in potato varieties. The protein synthesizer gene was isolated from *Amaranthus hypochondriacus*. It contains 3-4 times more essential amino acids.

Conclusion

The potato breeding program in India has made significant progress in recent years, developing new varieties that are more productive, resistant to pests and diseases, and better adapted to local conditions. This has helped to increase potato production in the country and improve the livelihoods of potato farmers. The program has also played a role in promoting the adoption of improved potato cultivation practices, such as seed potato production, nutrient management, and integrated pest management. This has helped to improve the overall efficiency and sustainability of potato production in India.

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