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Potentiality of Ploidy Breeding in Tropical Fruit Crops

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Abstract

The basic principle of plant breeding is utilization of existing variation and creation of new variation for developing a new variety. Ploidy breeding is one of the important tools used for crop improvements. It is mainly of two types *i.e.* euploidy and aneuploidy. It may occur naturally or can be induced by artificial means. Ploidy breeding is an important tool for widening variability in tropical fruit crops with narrow genetic base like banana. It has really wide implications in obtaining bigger fruit size and disease resistant plant types. Induced polyploidy and subsequent breeding have led to development of some useful types in *Annona squamosa* L., *Syzizium cumini, Zizyphus mauritiana, Psidium guajav* L., *Aegle marmelos*. Since these fruits are vegetatively propagated and their seed is of secondary importance, they offer a wide scope for polyploidy breeding.

Introduction

The basic principle of plant breeding is utilization of existing variation and creation of new variation for developing a new variety. Ploidy breeding is one of the important tools used for crop improvements. Ploidy is a term referring to the number of chromosome sets in somatic cells of the diplods (2n) or gametophytic cells of the haploids (n).

The discovery of colchicine for inducing polyploidy increases the scope of crop improvement apart from overcoming the sterility of hybrid crops. After polyploidization, the hybrid becomes fertile and can thus be further propagated. It was hoped that productions of autoploids in various crops could directly lead to the production of better plants, as generally the autopolyploids are known to have better characters than that of diploids. Similarly exploitation of aneuploids mostly the monosomic and trisomic condition can help plant breeder to develop desirable variety.

Classification of Ploidy

The somatic chromosome number of any species is designated as '2n' and the chromosome number of gametes is denoted as 'n'. An individual carrying the gametic chromosome number 'n', is known as haploids. A Monoploid, on the other hand, has basic chromosome number 'x'.

Ploidy can be classified into monoploid (1x), diploid (2x) and polyploids *i.e.*, Organism having more than two sets of homologous chromosomes *i.e.*, Triploids (3x), Tetraploids (4x), Pentaploids (5x), Hexaploids (6x), Heptaploids/ septaploids (7x), Octoploids (8x).

Based on levels of ploidy, two groups of plants are recognized *i.e.*, euploids and aneuploids.

➢ **Euploids:** They are the species with the exact multiple of the basic chromosome no. Depending on the composition of the genome, euploids can be further classified into either autopolyploids or allopolyploids. Tetraploidy is the most common class of euploids.

➢ **Autopolyploids:** Autopolyploids is containing over two copies of the essential set (x) of chromosomes of the same genome. Natural autoploids embrace crops admire alfalfa, peanut, potato, bananas. They mostly occur through the tactic of body doubling. Seedless watermelon is that the instance of artificial autoploids that manufacture by in vitro body doubling.

Autopolyploids may be originated by various way one such method is Colchicine treatment.

Colchicine Treatment

It is the most effective and the widely used treatment for polyploidy production. Colchicine is an alkaloid, which is found in the seeds and bulbs of autumn crocus (*Colchicum autumnale*). It can be used in aqueous solutions, in paste with lanolin, in glycerine or in agar. It's low concentrations are applied to the lethal buds or growing tips of the desired plants. Colchicine acts as spindle suppressors at mitosis and results in cells with double number of chromosomes per cell. Some examples of colchicines treatments are:

• Seed treatment: 0.001-1% for 1-10 days.

• Seedling treatment: Shoots of young seedlings for 3-24 hrs.

• Growing shoot apices: 0.1-1.0% colchicines for once or twice daily for a few days.

• Woody plants: 1% colchicines on shoot buds.

• Other chemical agents: Acenaphthene, 8- hydroxyquinoline, nitrous oxide *etc*., which have polyploidizing effect.

➢ **Allopolyploids:** Also called alloploids. They are a combination of genomes from different species. They result from hybridization of two or more genomes followed by chromosome doubling or by the fusion of unreduced gametes between species. It can be further classified into allotriploid, allotetraploid, allopentaploid, allohexaploids and so on. This process is key in the process of speciation for angiosperms and ferns and occurs often in nature. Economically important natural alloploid crops include strawberry, wheat, oat, upland cotton, oilseed rape, blueberry and mustard.

➢ **Aneuploids:** The change in chromosome number may involve one or few chromosomes of the genome and this is known as aneuploidy.

Further classified into:

• Two chromosome no. is missing (2n-2) - **nullisomis**

• One chromosome missing (2n-1) - **monosomics**

• Two chromosomes missing belong to different chromosome pairs (2n-1-1) - **double monosomics**

• One extra chromosome (2n+1) - **trisomics**

• Extra chromosome each belonging to a different chromosome pair (2n+1+1) - **double trisomics**

• One extra pair of chromosome (2n+2) - **tetrasomics**

The breeder is generally concerned with monosomics, and trisomics and in some situations with nullisomics and tetrasomics.

Use of Ploidy Breeding in Fruit Crops

Banana

It was reported that doubling of somatic chromosomes in root tip cells of wild and cultivated species of banana where majority of cells were having chromosome number (2n=2x=22). Occasionally abnormal cells with double the chromosomes were observed (2n=2x=44).

Bhaktavathsu *et al.* (1968) compared the natural tetraploids 'klue teperad' and Sawai'. They showed different morphological characters like sturdiness of the plant, pseudostem colour, blotching, petiole canal, bunch hanging, fruit colour, shape and size, presence and absence of male bud.

Vakili (1962) induced polyploidy in Musa species using colchicines treatment. They used seeds of open pollinated *M.balbisiana* and *M. balbisiana* X *M. acuminata.* Seeds were soaked in water for 5 days at 35 °C. Seeds in 4 stages of germination I, Intact seeds II, seeds with dislodged micropilar plugs III, Emerged seedlings showed epicotyls and beginning of primary roots IV. Seedlind with coleoptyle like first leaf were taken for treatment in seedling stages at III and IV gave higher percentage of tetraploid plant with reduced mortality. Tetraploids were having drooping thick leaves with short petiole but sturdier than diploid. Growth rate of tertraploid was much slower.

In musa colchicine-induced autotetraploids, have been proposed as a means of introducing disease resistance into banana breeding programs.

Citrus

Polyploidy breeding seems to offer prospects to obtain large sized fruit with dwarf plant types. Production of triploids by crossing tetraploid with diploids may be useful in obtaining seedless varieties. The seedless lime (*C. latifolia*) a triploid. Triploids have favorable characteristics and yield well but they are sterile. The development of triploid through breeding is very limited.

'Oroblanco' is the result of crossing of tetraploid and diploid. It is an early-maturing, seedless grapefruit type used in interior of California. It's fruit quality has not been satisfactory in cool, humid climate zones of other citrus area. Astrigency taste was noticed in early season and cooler area.

'Melogold' is the result of crossing of tetraploid and diploid.

It is an early, maturing seedless, hybrid of grapefruit used in interior of Calofornia. Fruit quality was not satisfactory in cool, humid, or in hot desert areas. The flavour of Melogold differs from both Oroblanco and grapefruit and is more like pummelo.

Tree and fruit characters of citrus triploids from 6 crosses involving tetraploid grapefruit lemon as seed parents and 5 diploid varieties as pollen parents, were examined. In a field trial 91 hybrids showed satisfactory vigour, but only 15 gave high yield. Seeds number were almost consistently low in all. Among 85 repopulated hybrids in a secondary trail have maintained good vigour upto 8 years after planting and 23 gave higher yield. Seed number were usually less than 5. Hybrids with tetraploid lemon as seed parent was lesser in seed no. than those of tetraploid grapefruit. TSS was generally intermediate as compared to the parent varieties.

Grapes

Some of the tetraploid grape varieties are commercially grown in India because of the large berry size and early ripening. But most of the tetraploid varieties have poor growth habit, irregular fruit set and reduced yield. It is impossible to predict the effects of doubling the chromosome no. of a given variety on its growth habit and fertility.

Over 2 year period polyploidy was successfully induced by colchicine treatment in 10 varieties and selection of bunch grapes adopted to the North Eastern United States, one in *V. vinifera* grape of California, and 16 muscadine grapes adopted to the Southern United States.

The crossing of diploid with induced tetraploids may help in evolving new triploid seedless grapes. But the triploids are highly sterile. Allotetraploids even between infertile species have been more desirable as commercial varieties.

Several method of colchicine treatments were tried in grapes and tetraploidy succefully induced in 11 out of 13 varieties tried. Seedling and bud treatment gave positive results while seed treatment was ineffective. Their application of 0.2% colchicine at cotyledonary stage on alternative stage had been found effective. Treatment of axillary buds with 0.25 and 0.50% colchicine and glyserine on alternative days for 3 days was found to be best. Although varying success was obtained from different varieties, a maximum 29% tetraploid was obtained in the variety Beauty Seedless.

Marvel Seedless from Delight, Early Niable (*Campbell* x *Niagra*), Lonetto, Early Giant from Campbell, Muscat Common Hall from Muscat Alexandria, Black King from Campbell, Wallis Giant from Concord, Case from Sultana etc. are few examples of polyploidy.

Guava

Producing triploids will be futile since the fruit shape in triploid is highly irregular and misshapen because of differential seed size. However, to evolve varieties with less seeds and increased productivity, crosses were made at IARI, New Delhi, between seedless triploid and seeded diploid variety Allahabad Safeda.

Since guava is vegetatively propagated fruit, it would be feasible to retain their requisite no. required for seedlessness. This study was attempted to standardize the technique induce tetraploidy in guava in Allahabas Safeda and L-49 (Ramkumar 1975). Colchisine was applied by using dip and cotton plug method. Ploypoids plants were identified based on the morphology. Best result was obtained by colchisine conc. of 0.1% for 24 hours. Speed of growth in unaffected cells overcomes the polyploid cells.

The breeding behavior of aneuploids of guava such as trisomics, tetrasomic and higher aneuploids has been studied. Reciprocal crosses between aneuploids and diploids indicated less than 100% crossability. When the aneuploids were used as male parents the differences were observed fruit size, fruit wt, seed no. The extra chromosome was found to be transmitted through both egg cells and the pollen. However, the frequency of transmission was more in egg cell 26% more than pollen.

Aneuploid has been widely accepted for its great value in fundamental genetics. Seeds from open pollinated triploid and cross between triploid and diploid were very big, medium and small. Only big seeds (50%), medium seeds (17%) and small seeds (88%) yield in aneuploid.

The tetrasomics were usually shorter than the trisomics. They found that tolerable limit of extra chrosome upto 4 and this limit seed fertility and fruit shape was adversely affected.

Pineapple

Tetraploids were produced by treating the growing point of pineapple variety Cayenne with colchicine. The fruits obtained were small with fewer but larger eyes and low TSS. Tetraploids are characterized by fewer but wider leaves, lower dry matter content, late maturity.

Mango

Spontaneous polyploidy seedlings from polyembroynic diploid mango cultivar Gomera-1 by Flycotometry analysis confirmed the tetraploidy. They have wider leaves, larger fruit than diploids. Much scope exists for polyploidy breeding. Vellaikolumban cultivar of mango is tetraploid in nature (2n=4x=80) which is a polyembryonic type it can be exploited for ploidy breeding.

Pomegranate

Production of tetraploids was achieved by colchicine treatment of leaf segment culture. The leaf segments were treated with p-flurophenyl-alanine reduced callus and adventitious bud formation and gave regenerated plants with haploid, aneuploid and tetraploid cells.

Conclusion

Induced polyploidy and subsequent breeding have led to development of some useful types in *Annona squamosa* L., *Syzizium cumini, Zizyphus mauritiana, Psidium guajav* L., *Aegle marmelos.* Since these fruits are vegetatively propagated and their seed is of secondary importance, they offer a wide scope for polyploidy breeding. The ultimate aim should be to develop tetraploid so as to evolve better types, which may grow vigorous, fertile and also may combined with other desirable characters. Polyploid types can be established under natural condition as well as agriculture, if only right genetic combinations and proper environmental condition is found. Therefore, induced polyploidy can be a useful line of work for plant breeders.

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