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Review Paper

POLYPLOIDY IN VEGETABLES

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Abstract

Polyploids are organisms with three or more complete chromosome sets. Polyploids were marked with phenotypic and genotypic variations. Beneficial variations can be further used in plant breeding programmes. Several abnormalities were also reported. Successful induction of polyploidy can also result in change in taste. In watermelons sweetness order was 3x > 4x > 2x. Polyploidy was found to be induced by colchicine, colchamine, oryzalin, colcemid, trifluralin etc. Chromosome doubling was achieved by different concentrations of colchicine. Review of polyploidy in vegetable crops *Viz.,* Cabbage, Brussels sprouts, Pea, Watermelon, Muskmelon, Onion, Garlic, Carrot, Radish, Cocoyam, Pointed gourd, Bitter Gourd, *Snake gourd,* Fluted pumpkin, Cucumber, And French Bean was undertaken.
Key words: Polyploidy, Vegetables, Breeding, Colchicine.

INTRODUCTION

Polyploids are organisms with three or more complete chromosome sets. Polyploidization is widespread in plants and animals, and is an important mechanism of speciation. The formation of fertile polyploids not only promoted the interflow of genetic materials among species and enriched the species diversity, but also laid the foundation for polyploidy breeding. The study of polyploids has both important theoretical significance and valuable applications. The production and application of polyploidy breeding have brought remarkable economic and social benefits. (Can, 2012).

Polyploidy is responsible for the creation of thousands of species in today's planet, and will continue to do so. It is also responsible for increasing genetic diversity and producing species showing an increase in size, vigour and an increased resistance to disease. Polyploidy is a prominent force of shaping the evolution of plants (Winge, 1917).

There are three documented or obvious advantages of becoming polyploid. The first two, heterosis and gene redundancy, are the result of gene duplication, whereas the mechanistic connection to polyploidy of the third, asexual reproduction, is unclear. Heterosis causes polyploids to be more vigorous than their diploid progenitors, whereas gene redundancy shields polyploids from the deleterious effect of mutations (Comai, 2005).

Polyploids were successfully produced by treating plant parts with colchicine, colchamine, oryzalin, colcemid, trifluralin, amiprophosmethyl (APM*)* etc. Although colchicine remained the most used for induction of polyploidy.Chromosome doubling was achieved by different concentrations of colchicine (Kazi, 2015).

Polyploidy in Vegetables

Cabbage

Tetraploid forms of Ladoza and of Langendeikskayazimnyaya [Langendijk Winter] were roughly equal to the diploids in germination and were slightly earlier but formed somewhat fewer heads, which were also smaller, had lower contents of ascorbic acid and were more apt to split. Some triploids from crossing diploid and tetraploid forms of the same cultivar were better than the diploids in yield and quality (Prikhod'ko, 1974).

In experiments to determine the optimum concentrations and length of treatment necessary for the successful production of polyploids using colchicine and colchamine, it was found that the latter was required in higher doses than the former (Goryachev, 1972).

Brussels sprouts

Haploid plants were treated with colchicine and scored for the presence of diploid flowers and for seed set after self-pollination. When colchicine treatments were applied after the plants had been vernalized, using 2 dose rates and either injection or external application, 38.1% of plants became doubled and 13.8% produced seed. When 0.05% colchicine solution was injected into plant apices at various times during vernalization, the mean rate of doubling was 71.2% and 50.7% of plants set seed (Currah, 1976).

Pea

Tetraploids were induced at 15-20% frequency by treating 1.5-2 cm long seedlings of 4 cultivars differing in geographic origin with 0.025% colchicine for 4 h. The large-seeded cultivars T163 and 68C gave more tetraploids than did the small-seeded 5064S and PI280064. Tetraploids showed significant varietal differences and were characterized by large stoma, flowers and seeds. Compared to diploids, the tetraploids had increased pod width, delayed flowering and maturity and reduced stomata frequency and pod length. Colchicine treated diploids showed pollen and ovule sterility ranging from 16 to 56% and 7 to 56%, respectively, but had no chromosome abnormalities (Mercy kutty, 1983).

Watermelon

Triploid (3X) hybrid watermelons, first produced by Kihara and Nishiyama in 1939 are a classical example of the use of colchicine induced polyploids for the production of seedless fruit. The creation of a tetraploid variety is a prerequisite to the production of seedless hybrids. While induction by colchicine in itself is comparatively easy and effective, the maintenance of tetraploid watermelon lines at a stable level is a required capability that must be proved experimentally. Production of triploid hybrid seed by the original and costly process of hand pollination of 4X x 2X parents must be rejected for practical reasons. Natural crossing by bee pollination in field plots seems the efficient answer to seed production. In triploids Sweetness is notably higher and more stable than in the diploid parents. Insufficient disease resistance has been one of the limitations preventing the wide use of triploids (Andrus, 1971).

Polyploids are desired to produce seedless fruits in watermelon. *In vitro* techniques pave way towards production of tetraploids by culturing explants on media containing colchicine. Cotyledon, embryonic end of seed, epicotyl and hypocotyl

explants were cultured on MS media supplemented with BA (1 mg L-1). Shoot proliferation response was maximum in cotyledonary explants cultured on 0.01% colchicine level for four days. DNA content was found double in tetraploids (4.41µg mL–1) than diploids (2.18 µg mL–1) in unit gram of sample. Cotyledon explants cultured on colchicine supplemented medium (0.01%) for four days resulted in maximum tetraploids (Raza, 2003).

Triploids and tetraploids obtained after colchicine treatment had rounder fruits, seeds and cotyledons, larger flowers and larger and thicker leaves than diploid plants. Chloroplasts/guard cell increased in proportion to chromosome number. The pollen grains were larger in tetraploid than in diploid plants. Triploid plants produced very large and very small pollen grains in the same anther. No fruit were set after selfing triploid plants owing to poor pollen viability. Pollen grains from diploid plants were the most viable. Selfingtetraploid plants gave lower percentages for fruit and seed set than did 4x (female) X 2x (male) crosses; 3x (female) X 2x (male) crosses gave seedless fruits. Fruit sweetness was in the order 3x > 4x > 2x (Sinchai, 1982).

Muskmelon

Muskmelon seedlings were sprayed weekly with 0.1, 1, 10 or 100 p.p.m. colchicine. The treatments suppressed the appearance and further development of staminate flowers, induced the differentiation of hermaphrodite flowers at a lower node and also increased their number. Colchicine induced pollen sterility but did not affect ovule fertility (Bisaria, 1982).

Two 4x = 48 plants were induced in Muskmelon variety Delta Gold, and the plant, floral and fruit characteristics are compared with those of the diploid. The fruits were smaller but of better quality and contained viable seed (Rajasekaran, 1971).

Onion

Several *Allium cepa* X *A. fistulosum* and reciprocal crosses were treated with colchicine. The C2 populations had shown good seedling vigour and winter hardiness at Beltsville during the winter (McCollum, 1982).

In achieving chromosome doubling in the root meristem cells, the best results were obtained by colchicine treatment with 0.05 and 0.1% concentrations for 10 and 16 h. The highest output of autopolyploids from cultivating treated seedlings was 40.6%, the tetraploids amounting to 12.4% (Vodyanova, 1974).

Garlic

Trifluralin, a type of herbicide, has been reported to provoke chromosome doubling. However, this chemical had not been tested on garlic. varioustrifluralin concentrations and treatment durations were tested for efficiency in the induction of tetraploid garlic. A clove base of garlic with a stem cv. Gailiang was used as the ex-plant to induce calluses on Murashige and Skoog (MS) medium; the calluses were then inoculated onto MS medium containing different levels of trifluralin and cultured to induce chromosome number variation *in vitro*. However, increases in trifluralin concentration and treatment duration reduced the survival rate (Cheng, 2012).

Carrot

Colchicine treatments of a limited duration, followed by regrowth in a colchicine-free medium, showed that spread of cycle times in the diploid culture prevented uniform induction of tetraploidy (Bayliss, 1976).

Radish

Mean chromocentre frequency decreased significantly with increased colchicine concentration and duration of treatment, and at 0.3% aqueous solution chromocentres were not visible in Radish i.e. *Raphanussativus* L. (Ahmad, 1987).

Cocoyam

Colchicine was applied in liquid B5 medium supplemented with 0.49 _m N6 (*1*2-isopentenyl) adenine to tissue culture derived cocoyam plantlets. Tetraploids (4n=52) and octoploid (8n=104) were produced by treating plantlets with 1.25 mM and 2.50 mM colchicine. Non-treated plantlets and plantlets treated with dimethylsulphoxide (DMSO) had typical diploid chromosome counts, 2n=26 (Tambong, 1998).

Pointed gourd

The applicability of induced tetraploidy for the improvement of pointed gourd, *Trichosanthesdioica*, was investigated by treating the apical meristem of five-day-old seedlings with 0.2% colchicine. The putative colchiploid plants grew slowly and had abnormal morphology. No fruits were set following hand pollination. The pollen grains of colchiploids was larger but less viable than those of diploids (Hazra, 2001).

Bitter Gourd

After treatment of a two-month-old normal diploid plant of Bitter gourd i.e. *Momordicacharantia* L. with colchicine, a branch emerging from the basal node was observed to have the tetraploid chromosome number, leaves, flowers, stomata and pollen of irregular size and an abnormally high incidence of pollen sterility (Wanjari, 1973).

Snake gourd

Tetraploids were obtained following colchicine treatment of diploid *T. anguina.* The diploids and tetraploids were crossed to produce triploids. Meiosis was regular in the diploids but it was irregular in the triploid and tetraploids. The tetraploid had larger leaves, flowers and pollen grains than the diploid but the fruits of the tetraploids were smaller and of abnormal shape. Pollen fertility in the tetraploid, triploid and diploid was 76.5%, 0% and 98.90%, respectively (Singh, 1975).

Pollen sterility increased in the generation following the treated one with increase in X-ray dose and colchicine concentration. Colchicine treatment resulted in larger pollen grains. Experimentally produced tetraploids had larger pollen grains than diploids and triploids (Basu, 1977).

Seeds of *T. anguina* [*T. cucumerina*] were treated Colchicine (0.5%). Both male and female flowers were much larger than those of control plants. More branches and leaves were produced in colchicine treated plants (Sardar, 1988).

Fluted pumpkin

Mitotic studies were carried out on fluted pumpkin (*Telfairiaoccidentalis*Hook. F.) lines collected from South East, South West, South South and North Central geopolitical zones of Nigeria where the crop ismainly cultivated. The results obtained revealed diploids (2n = 22), aneuploids (2n = 22 + 1), triploid (3n= 3x = 33) and tetraploid (4n = 4x = 44) chromosome numbers among the cells investigated (Uguru, 2011).

Cucumber

Treatment of the parthenocarpic variety of Cucumber i.e. *Cucumissativus*Butchers Disease Resisting with colchicine resulted in the production of an autotetraploid, which at first gave better yields than the diploid. The autotetraploids had lower self-fertility than the diploids and, when crossed with the diploids, gave triploid plants. The triploids were self-sterile (Grimbly, 1973)

French bean

By treating meristems of germinated seeds of French bean one variety of each of the species with 0.1 and 0.2% colchicine solutions, autotetraploids (2n = 44) of *Phaseolus vulgaris* and *P. coccineus*were obtained. The tetraploids of all species had

darker, more hairy leaves and slower growth than the diploids, flowered later and produced larger flowers. They had a reduced seed set (Nikolova, 1986).

CONCLUSION

Polyploidy is a common phenomenon in vegetable crops. Polyploids produced larger fruits, flowers and leaves. At times abnormalities were also reported. Tetraploidy induced pollen sterility in many crops. Maintenance of tetraploid seeds is difficult. Triploids in watermelon were seedless and were sweeter than tetraploids and diplods. Triplods can be produced by crossing 4X (Female) and 2X (Male). Polyploidy was found to be induced by colchicine, colchamine, oryzalin, colcemid, trifluralin etc. Chromosome doubling was achieved by different concentrations of colchicine. Polyploidy or chromosome doubling was successfully induced in vegetable crops *Viz.,* Cabbage, Brussels sprouts, Pea, Watermelon, Muskmelon, Onion, Garlic, Carrot, Radish, Cocoyam, Pointed gourd, Bitter Gourd, *Snake gourd,* Fluted pumpkin, Cucumber, *Sweet Potato*, Potato, Tomato, Chilli, Bell Pepper, Eggplant And French bean.

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