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Polyploidy In Solanaceous Crops

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ABSTRACT

Solanacae is an economically important including number of important Crops *Viz.*, Tomato, Potato, Chilli, Bell pepper, Egg Plant, Tomatilo. Polyploids are valuable sources of genes for disease resistance and stress tolerance and genetic variation. Polyploidy or chromosome doubling induced changes in morphology and cytology. Morphological changes included change in fruit and flower shape, size, number of leaves or branches and even abnormalities were reported.

Polyploidy was found to be induced by colchicine, oryzalin, colcemid, trifluralin etc. Chromosome doubling was achieved by different concentrations of colchicine. Review of polyploidy in Solanaceous crops *Viz.*, Tomato, Chilli, Chilli Pepper, Potato, Tomatillo, Nicotina, African Nightshade, Datura and Eggplant was undertaken.

Keywords: Polyploidy, Colchicine, Solanaceae, Vegetables

Introduction

The Solanaceae, or nightshades, are an economically important family. It includes a number of important agricultural crops, medicinal plants, spices, weeds, and ornamentals. Many members of the family contain potent alkaloids *viz.*, Solanine, Nicotine, Capsaicin, Tropanes. The most economically important genus of the family is *Solanum*, which contains the potato (*S. tuberosum*, in fact, another common name of the family is the "potato family"), the tomato (*S. lycopersicum*), and the eggplant or aubergine (*S. melongena*). Another important genus, *Capsicum*, produces both chili peppers and bell peppers.

Polyploids are organisms with three or more complete chromosome sets. Polyploidy induction is expected to increase its breeding potential (Torres, 2011). The discovery of colchicine's chromosome doubling effect (Blakeslee and Avery 1937) led to its use as an important tool for the experimental study of polyploidy. Presently, colchicine ($C_{22}H_{25}O_6$) extracted from seeds or corms of autumn crocus (*Colchicum autumnale*) its synthetic analogue; colcemid and oryzalin are some of the agents used to achieve chromosome doubling. For chromosome duplication, colchicine is generally appliedto meristematic cells, usually the shoot primordial using cotton pads, or by dipping the tissues in the colchicine solution. Treatment of pre-soaked seeds is also effective. The concentration of colchicine solution and duration of application varies with plant species. Correct determination of colchicine dosages for use in chromosome doubling is important as high colchicine dosages can cause plant death due to its toxic effect (Navarro-Alvarez *et al*. 1994).

Polyploids are valuable sources of genes for disease resistance and stress tolerance and genetic variation (Plaisted and Hoopes, 1989).

2.1 Tomato

When seeds of *Lycopersicum esculentum* Miller (Solanaceae) were pre-soaked in a 0.4% colchicine solution for 2, 4, 6 or 8 days, the 4, 6 and 8-day treatments delayed emergence progressively. About 1.45% of cells were polyploids. The 4-day treatment induced chromosome doubling and gave the highest percentage (95%) of pollen fertility. The treatments up to 6 days gave progressively higher mean pollen grain diameters (Ugborogho, 1985).

In the variety Best of All, plants with spotted leaves were produced after seed treatment with diethyl sulphate, dwarf plants resulted from treatment with colchicine or diethyl sulphate, and all three chemicals resulted in abnormal leaves (Bose, 1969).

Preirradiation treatments with colchicine and diethyl sulphate followed by 10, 20, 30 or 40 kR X-ray doses led to seedling and plant mutations and chromosome aberrations. A 40 kR dosage was lethal and mutation in the M2 was proportional to the X-ray dose given. There were many fasciated plant types involving stems, flowers and fruits (Bose, 1972).

Seeds of the variety Best of All were treated with colchicine or diethyl sulphate before being exposed to X rays. Mitotic and meiotic chromosome aberrations, such as fragments,

bridges and clumping, were observed. Lethal seedling mutants were seen in the M2 as well as twelve types of plant mutants in which habit, height, leaves and flowers were affected. The mutants dwarf sterile, extreme dwarf, necrotic slender stem and stem fasciation were completely sterile (Bose, 1973).

The tetraploids differed from the diploids in a number of characters. The tetraploid had larger stomata and pollen grains and a thicker leaf. The tetraploids also had a slower growth rate and a lower yield (Litvinenko, 1975).

A male-sterile parthenocarpic line was treated at various stages (seed, cotyledon, first pair of true leaves and 7-8 leaves) with 0.1, 0.2 and 0.3% colchicine for 24, 28 and 32 h. Treatments at the cotyledon and first-leaf stage proved effective in polyploid production (only colchicine concentrations >0.1%). The highest percentage of polyploids (55.5%) was obtained by soaking plants with the first pair of true leaves in a 0.3% aqueous solution of colchicine for 32 h. Some C0 plants had larger leaves than the untreated controls, bigger flowers and larger fruit, but they set few seeds (Balkanjieva, 1988).

Diploid and tetraploid plants of Moneymaker were compared in the C3 and C4 generations. The tetraploids were superior in flower diameter and number, fruits/plant, 1000-seed weight and total carbohydrate and soluble sugar contents in fruits but were inferior in fruit diameter and yield, seeds/fruit, seeds/plant, seed yield/plant and ascorbic acid content of fruits. Diploid and tetraploid plants were similar in flowering period and general pattern of flowering behaviour (Megahed, 1984)

2.2 Chilli

Meiosis was studied in plants grown from seeds treated with 0.4 and 0.2% aqueous colchicine solution for 24 and 72 h, respectively. Nine of the 13 plants treated with 0.4% had one to three interchanges/plant and 77-89% pollen sterility (Rao, 1983).

Colchicine treatment of seeds and seedlings of C. annuum var. cerasiformis and of the variety TNK produced a range of cytological and morphological abnormalities. Morphological and cytological variants occurred more frequently in var. cerasiformis than in TNK. Large fruit, curly leaves and chromosome stickiness were transmitted on selfing, thus suggesting that these traits may be mutations induced by colchicine (Kumar, 1988).

Following 1% colchicine seed treatment, tetraploid plants of *Capsicum annuum* cultivars Shishitoh 562, Chigusa and Jalapeno were obtained. Fruit morphology and seed numbers of diploid and tetraploid plants were compared. Mean seed numbers of tetraploid plants of the 3 cultivars were 18% of the diploid plants, fruit length of the tetraploids was 74% of the diploids. Fruit shape also showed slight differences (Ishikawa, 2002).

Polyploidy was induced in hot pepper (*Capsicum annuum* cv. 'GVC-111') using colchicine and tetraploid plants with robust root size system were obtained. Chromosome doubling was achieved by different concentrations of colchicine (0.05%, 0.1%, 0.2% and 0.4% aqueous solution) to either presoaked seeds or to the shoot tip of young seedlings for 24, 48 and 72 h, respectively. Out of 313 putative polyploids, 31 were tetraploid, 270 were mixoploid and 12 were, in fact, diploid. This study demonstrates successful utilization of colchiploidy to create novel mutations for root size systems (Kulkarni, 2010).

2.3 Chilli Pepper

Following colchicine treatment, a plant of Chilli Pepper cv. Co2 was found to have chromosome numbers ranging from 2n = 38 to 96. It had 4.95% pollen fertility and set no seed, and its growth was stunted (Rao, 1987).

Polyploids are generally characterized to have large flowers and pollen grains (Watts, 1980). Tetraploid plants of *Capsicum annuum* L. 'Chigusa' (Nihon Horticultural Production Institute) were obtained by colchicine treatment of seeds (Ishikawa et al., 1997). Flow cytometric analysis (Partec PA flow cytometer, Partec, Munster, Germany) showed that ≈20% of the seeds treated with colchicine were tetraploid, comparable with our previous report (Ishikawa et al., 1997).

The tetraploid plants had larger flowers than did plants of the diploid counterpart. While diploid flowers typically had six petals and stamens, tetraploid flowers typically had seven petals and stamens. Tetraploid plants had 20% larger ovaries and 25% larger diameter pollen grains than diploids (Ishikawa, 2001).

The plant materials were diploid cultivar 'Shishito No.562' and its tetraploid counterpart. Both polyploid plants were allowed to bear 0, 3 and 7 fruits to control plant vigor. Higher dry weight in leaf, stem and root was obtained in the tetraploid plant as compared with the diploid one. Leaf area and thickness of the tetraploid plants increased. The tetraploid plants had higher uptakes of water, NO_3-N and K. These results indicate that tetraploid plants have higher uptakes of water, N and K, with a consequent increase in leaf area and the amount of photosynthate, and bear smaller but uniform size fruits, independent of fruit loading (Takizawa, 2008).

2.4 Potato

A study was made of changes in the characters of a number of species when their chromosomes were doubled. The species differed in their reaction. From a large diversity of polyploid forms, homozygous breeding lines were

produced which were resistant to various diseases and pests (Lebedeva, 1974).

Colchicine was applied on sprouting bud and subsequent selected buds of Bangladeshi local potato. Colchicine treatment showed an increase effects in plant height in the variety of Hagrai, Silbilati & Lalpakri and the var. of Challisha showed no increase result besides, negative impact showed in var. Indurkani, JPR, Goforown and Shaita. The var. of Hagrai and Lalpakri at all the intervals produced highest number of tubers than rest of varieties. In all intervals Lalpakri obtained the best performance after Colchicine treatment. This might be explained that colchicine treatment enhances plant height, results in more fresh weight of plant and number of leaves, which consequently increase the number of tuber and finally increase total fresh weight of tubers of potato (Alam, 2011).

These polyploids are often sources of valuable genes for potato breeding. *Solanum demissum*, for example, has been the main source of many key blight resistance genes. With a clearer view of the origins of the genomes in these polyploids, we are now in a better position to decide where, for example, novel resistance genes are likely to be found (Bryan, 2011).

About 70% of these wild species are diploid at $2n = 2x = 24$, with the remaining species polyploid, mostly at the tetraploid ($2n = 4x = 48$) or hexaploid ($2n = 6x = 72$) levels. These polyploids are valuable sources of genes for disease resistance, stress tolerance, and improved tuber quality in potato (Plaisted and Hoopes, 1989).

2.5 Tomatillo

Tomatillo (*Physalis ixocarpa* Brot.*)* is a native species of Mexico and Central America, ranking fourth in cultivated area among main vegetables in Mexico. Husk tomato autotetraploid and diploid populations were evaluated for yield and fruit quality. The chromosomal duplication in husk tomato *Physalis ixocarpa* contributed to the change in the shape of the fruits which flattened at the poles with the presence of gaps between the endocarp and the mesocarp. The vitamin C content in autotetraploids was enhanced which contributed to the improvement of the fruit nutritional quality. It is noteworthy that the evaluated autotetraploids are materials needing a process of selection and chromosomal stabilization in order to achieve the full expression of their genetic potential (Godina, 2013).

The tomatillo, *Physalis ixocarpa* Brot. (2n = 2x = 24), is an important crop in Mexico. Young seedlings of the Rendidora cultivar were treated for 24 h with colchicine in concentrations ranging from 0.04% to 0.20%, and ploidy levels were tested by cytological and flow cytometry techniques. Autotetraploidy was induced with colchicine concentrations of 0.12% and 0.16%, with success rates of 67% and 65%, respectively The polyploid plants showed higher values for life cycle length, plant height, fruit weight and equatorial diameter, fruits per plant, and soluble solid concentration (Torres, 2011).

2.6. Nicotina

Nicotiana alata belongs to family solanaceae. It is used as ornamental and drug. Seed of Nicotina were dipped in colchicine at concentration of 0.10, 0.25 and 0.50 % for 12, 24 and 48 hours. Colchicine treatments of *Nicotiana alata* seeds were very effective for producing a large number of tetraploid plants. Tetraploid plants showed an increase in the vegetative and flowering characters than the diploid plants with new ornamental characteristics. (Elham, 2009)

2.7 African Nightshade

Species belonging to this section, generally referred to as "*Solanum nigrum*-complex" are predominantly autogamous, favouring production of many small fruits and seeds, which compete with leaves for photosynthates. *S*. *nigrum*-complex constitutes a polyploidy series, with diploid ($2n=2x=24$), tetraploid ($2n=4x=48$), hexaploid ($2n=6x=72$) and rarely, octoploid ($2n=8x=96$) species. The natural tetraploid and hexaploid species are more genetically isolated from one another (Ojiewo, 2007).

2.8 Datura (Jimsonweed)

Several polyploid datura plants were developed by trifluralin and colchicine treatments and were compared with their diploid counterpart for vegetative and morphological characteristics. There were doses related effects of the ploidy treatments on quantitative traits resulting in reductions in traits such as plant height, number of leaves per branch, but increases in number of branches, number leaves per plant, leaf dry weight and chlorophyll content. This finding demonstrates the existence of genetic variation for the morphological response to ploidy change in *Datura sramonium (*Amiri, 2010*).*

2.9 Egg Plant

Besides normal diploids, individuals with 2n = 48, chimeras with 2n = 24-48 and others with 2n = 48-96 were isolated from seedlings grown from seeds treated with colchicine while germinating (Medina, 1972).

Seeds of the variety Santa Ginebra at different stages of development were treated with differing concentrations of colchicine for varying periods. The effect of the chemical varied with the stage of seed development. True polyploidy was not observed but plants with randomly distributed diploid and tetraploid sections were found after the treatment of germinating seeds with low concentrations and after pregermination treatment with 0.4% and 0.6% solutions (Medina, 1972).

Treatment of seeds of cv. Purple Pusa Long with DES [diethyl sulfate; 0.4 and 0.6%] produced an increase in fruit size, fruit weight and number of fruits per plant over 2 generations. Treatment with EMS [ethyl methane sulfonate; 0.4-0.8%] produced a smaller increase in these characters, while colchicine produced a high-yielding, spiny mutant. Seed germination was significantly reduced by all treatments, and m-nitrophenol was lethal (Siddiqui, 1986).

3. Conclusion

Solanacae family includes crops *Viz.*, Tomato, Chilli, Chilli Pepper, Potato, Tomatillo, Nicotina, African Nightshade, Datura and Eggplant. Tomatilo. Polyploids are valuable sources of genes for disease resistance and stress tolerance and genetic variation. Polyploidy or chromosome doubling induced changes in morphology and cytology. Morphological changes included change in fruit and flower shape, size, number of leaves or branches and even abnormalities were reported. Polyploidy was found to be induced by colchicine, oryzalin, colcemid, trifluralin etc. Chromosome doubling was achieved by different concentrations of colchicine.

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