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Review Article

POLYPLOIDY BREEDING IN VEGETABLE AND TUBER CROPS – A REVIEW

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Introduction

An organism or individual having more than two basic or monoploid sets of chromosomes is called polyploid and the condition is known as polyploidy. It is common in nature and provides a major mechanism for adaptation and speciation. At least half of the known angiosperm species have experienced polyploidy in their evolutionary history (Hieter and Griffiths, 1999; Shaked *et al.*, 2001; Xing *et al.*, 2010). Polyploidy induces "gigas" effect or gigantism that causes increase in cell size and hence, larger plant organs. Triploids have three sets of chromosomes and are sterile and hence, produce seedless fruits. This characteristic feature of seedlessness has been highly exploited in watermelon. Triploids not only provide seedlessness but also fetch higher yield as compared to diploids. For example, the Vertigo watermelon variety ($2n = 3x = 33$) gives a yield of 41,000 lb/acre (Cushman *et al.*, 2003). Polyploid organisms exhibit increased vigor and perform better as compared to their diploid counterparts. Besides this, polyploids have larger organs as compared to diploids. Polyploidy might occur naturally but it can be induced artificially by means of chemicals and other methods. Polyploidy has a good scope especially in small fruited spp. *e.g.* raspberry, cherry, grapes, ber, phalsa, mulberry etc. and also in leafy vegetables and asexually propagating tuber crops. It may also be used to enhance the production of secondary metabolites in medicinal plants. Larger flower and spike size would also be an advantage in ornamental crops.

The fact that a majority of plants undergo polyploidy has attracted breeders to exploit this mechanism further. In this review, the occurrence of polyploidy naturally and artificially with its importance and advantages especially in vegetable crops is summarized.

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The relative studies on polyploidy in vegetable and tuber crops are countable and those which have been published are reported here under.

Choudhury and Rajendran (1980) recorded ascorbic acid content of 50mg/100g in tetraploid *var*. Pusa Jyoti of palak which was higher as compared to diploid var. All Green.

Kagan-Zur *et al*. (1991) conducted a study on the fruit attributes of triploid tomato. Self-pollination failed to produce fruits but on auxin application the triploid fruit weighed 93.3g in summer and about 117.5g in winter which was 50% larger than its diploid fruit of 60.2g in summer and 78.5g in winter. Besides this, the protein content of triploid fruit was 3.7mg/g while that of diploid fruit was about 2.7mg/g. Overall, the triploid fruits had 30% more protein than its diploid counterparts. The triploids were also reported to be superior in terms of flavour.

Pair and Bruton (1997) conducted an experiment to study the relationship of watermelon genotype and ploidy to incidence of yellow vine disease. Incidence of yellow vine affected plants ranged from 1.7% to 45.0% in 'Sugar Baby' (4n) and 'Klondike', respectively. Diploid open-pollinated and hybrid cultivars had 63% and 41% higher incidence of yellow vine disease, respectively, compared to triploid seedless cultivars. The triploid and tetraploid cultivars recorded lower incidence. Sugar baby (4n) reported lowest incidence.

Sreekumari *et al*. (1999) studied the tuber yield of triploids and diploids of cassava. It was observed that the tuber yields of triploids were superior than the diploid cultivars. Similarly, the starch content (39.7%) and dry matter (46.5%) were higher in triploids as compared to diploids.

Suresh Babu and Rajan (2001) studied the characters of diploid, triploid and tetraploid little gourd. It was observed that the triploid took only 38 days to flower and the diploid took 40 days and the tetraploid 42 days. The fruit weight of triploid was 44.20 g while that of diploid was only 15.20 g. Besides this, triploid plant recorded 15.25 kg/vine/year which was much higher as compared to diploid plant. Also, the fruit size of triploid fruit was large while that of diploid was medium. The fruits of triploid had less pholyphenols and hence, they were tastier.

Sreekumari *et al*. (2004) studied the comparative performance of diploid and triploid taro. It was observed that triploids are superior to diploids in seven of the nine characters studied. The corm and cormel yield showed very promising and impressive increase in the triploids except in the case of cormel number which was significantly more in diploid plants. The leaf size was higher in triploids while the leaf number recorded no significant difference. The plant height of triploids was significantly higher.

Jaskani *et al*. (2005) conducted an experiment using seven tetraploid watermelon lines developed by colchicine treatments. These were compared with their diploid counterpart for plant, flower, fruit, seed and qualitative characteristics. Tetraploid genotypes attained statistically higher vine thickness (8.04 mm) and leaf area (298.9 cm^2) while internode length and chlorophyll fluorescence was similar to their corresponding diploid. Both pistillate and staminate flower organs (pedicel, anther, ovary, stigma, petals) were larger in tetraploid plants; however, the percent increase in flower components varied across the tetraploid lines. Fruit weight and total sugar content (°Brix) in both ploidy fruits was similar. Rind thickness in fruits varied significantly and averaged 12.7mm and 17.2mm in diploid and tetraploid fruits, respectively. Tetraploid genotypes showed sterility, yielded lower number of seed per fruit (37.9), and tetraploid seed was larger and thicker than diploid seed. Overall β-carotene (0.89), lycopene (1.16), fructose (5.43%) and glucose (2.38%) contents were higher in tetraploid than diploid fruits.

Zhang *et al*. (2010) conducted a trial to study the morphological characters and fruit quality of tetraploid muskmelon. The results indicated that the tetraploid fruit was distinctly bigger and heavier and its mesocarp was approximately 0.9 cm thicker than that of the diploid fruit. The tetraploid fruits recorded fruit horizontal diameter of 12.93 cm while that of the diploid fruit was 11.60 cm. Similarly, the fruit longitudinal diameter of tetraploid fruit was 13.37 cm while that of diploid fruit was 11.77 cm. The fruit weight of tetraploid fruit was 1376 g and that of diploid fruit was 1025 g. Besides this, the tetraploid fruit had soluble solid content of 16.10% while the diploid fruit recorded 13.50%. The total sugar of tetraploid fruit was 92.04 mg/g while that of diploid fruit was 70.60 mg/g. The vitamin C content of tetraploids was 13.08 mg/100g and that of diploid fruit was only 7.02 mg/100g.

Vijaylakshmi and Singh (2011) conducted an experiment to study the effect of colchicine on cluster bean. It was observed that the root length, shoot length and number of lateral roots increased significantly at all the concentrations (5, 10, 15, 20, 25 ppm) as compared to control. Similarly, the pod circumference was significant at 5 ppm conc. than control. The weight of seeds/pod was significantly higher at 5 ppm (148.8±28.93) and 10 ppm (109±16.81) concentration of colchicine as compared to control (59.75±4.8).

Bharathi *et al*. (2014) worked onto develop a new synthetic species of *Momordica* by crossing natural tetraploid *Momordica subangulata* subsp. *renigera* (2n = 56) with induced tetraploid *Momordica dioica* (2n = 4x = 56). The hybrid produces adventitious root tubers through which it perpetuates and propagates like its female parent and maintains its morphological characteristics in the progeny. The hybrid is naturally fertile and has the superior agronomic traits of both parents making it a good choice as a new vegetable crop. The new species is named *Momordica* x *suboica* Bharathi.

Kaveh *et al*. (2014) conducted an experiment to study the effect of different ploidy levels on glycoalkaloid content of four *Solanum melongena* cultivars. It was observed that the tetraploid accessions had lower glycoalkaloid contents than the diploids during fruit set. At harvest, there was no significant difference observed.

Liu *et al*. (2015) studied the characters of tetraploid pumpkin and observed that tetraploids plants had a descended female flower node position. The fruit weight of tetraploids was 2.9 kg while that of diploids was 2.2 kg. The seed count per fruit in tetraploid fruit was about 30 seeds as compared to diploid fruit (122 seeds). The photosynthetic rate increased by 90% in tetraploids while the flavonoids content increased by 50%.

Conclusions

Polyploidy has been widely studied in the last century and is arguably one of the most important mechanisms of adaptation and speciation in plants. Polyploidy breeding can act as an important tool for the evolution of new crop species. It can be highly beneficial to farmers as larger fruits or other parts tend to fetch more yield and price. It helps achieve improved biotic and abiotic stress resistance. Moreover, the fact that many of the most relevant crop species are polyploid has proven that polyploidy is also of great relevance for humans.

References

[1] Bharathi, L.K., Singh, H.S. and John, K.J. (2014). A novel synthetic species of *Momordica* (*M.* x *suboica* Bharathi) with potential as a new vegetable crop. *Genet. Resour. Crop Evol.* **61**(5):875-878.

[2] Choudhury, B. and Rajendran, R. (1980). Pusa Jyoti, a highly nutritive palak. *Indian Hort.* **25**(2): 5-6.

[3] Cushman, K.E., Horgan, T.E., Snyder, R.G., Hudson, P.M., Coker, C.H. and Ely, M. (2003). Evaluation of elongated and oval triploid (seedless) watermelon genotypes.Annual Report 2002 of the North Mississippi Research & Extension Center. Mississippi Agriculture & Forestry Experiment Station Information Bulletin, **398**: 339–345.

[4] Hieter, P. and Griffiths, T. (1999). Polyploidy – More is more or less. *Science*, **285**: 210–211.

[5] Jaskani, M.J., Kwon, S.W. and Kim, D.H. (2005). Comparative study on vegetative, reproductive and qualitative traits of seven diploid and tetraploid watermelon lines. *Euphytica,***145**: 259–268.

[6] Kagan-Zur, V., Yaron-Miron, D. and Mizrahi, Y. (1991). A study of triploid tomato fruit attributes. *J. American Soc. Hort. Sci*., **116**(2): 228-231.

[7] Kaveh, H., Nemati, H., Ahmadi, F. S. and Davarynejad, G. (2014). Effects of different ploidy levels on glycoalkaloid content of four *Solanummelongena* cultivars. *Adv. Env. Biol*., **8**(17): 48-52.

[8] Liu Ze-fa, Min Zi-yang, Sun Xiao-wu, Cheng Juan and Hu Yi-hong (2015). Study on induction and characterization of tetraploid plants in pumpkin. *J. North China Agri. Uni*., **30**(5): 125-129.

[9] Pair, S.D. and Bruton, B.D. (1997). Relationship of watermelon genotype and ploidy to incidence of yellow vine disease. "Cucurbitaceae'98: Evaluation and Enhancement of Cucurbit Germplasm" pp: 248-252.

[10] Shaked, H., Kashkush, K., Ozkan, H., Feldman, M. and Levy, A.A. (2001). Sequence elimination and cytosine methylation are rapid and reproducible responses of the genome to wide hybridization and allopolyploidy in wheat. *The Plant Cell*, **13**: 1749–1759.

[11] Sreekumari, M.T., Abraham, K., Edison, S. and Unnikrishnan, M. (2004). Taro Breeding in India. In: Guarino, L., Taylor, M. and Osborn, T. (eds) Pro. 3rd Taro Symposium, Nadi, Fiji.Secretariat of the Pacific Community. pp. 202-207.

[12] Sreekumari, M.T., Jos, J.S. and Nair, S.G. (1999). 'SreeHarsha': A superior triploid hybrid in cassava. *Euphytica*, **106**: 1–6.

[13] Suresh Babu, K.V. and Rajan, S. (2001). A promising triploid of little gourd. *J. Trop. Agric*. **39**: 162-163.

[14] Vijayalakshmi, A. and Singh, Anju (2011). Effect of colchicine on cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Asian J. Env. Sci*., **6**(2): 171-174.

[15] Xing, S.C., Cai, Y.H. and Zhou K.D. (2010). A new approach for obtaining rapid uniformity in rice (*Oryza sativa* L.) via a 3x × 2x cross. *Genet. and Molec. Biol.*, **33**: 325–327.

[16] Zhang, W., Hao, H., Ma, L., Zhao, C. and Yu, X. (2010). Tetraploid muskmelon alters morphological characteristics and improves fruit quality. *Scientia Horticulturae*, **125**: 396-400.