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Effect of Colchicine on Induction of Ploidy and Other Morphological Features of Different Crops: A Review

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Abstract

Colchicine is a mitotic inhibitor and it has been used for induction of tetraploids in different crops. Different concentration of colchicine has been used for different time period *in vivo* and *in vitro*. Colchicine is used for such purposes because rate of spontaneously doubling in most species is rare in tissue culture. Treatment of colchicine in *in vitro* culture plant tissues has been efficiently used to artificially produce polyploids in different plants. In different crops such as vegetables, fruits and flowers tetraploids produce variants with favourable horticultural characteristics like high yield, large fruit size and resistance to different environmental stresses. Tetraploids was induced *in vivo* by applying colchicine in an aqueous solution, lanolin paste, on apical shoot meristem of seedling and soaked seeds. Colchicine use has been found a very prosperous methodology for genome doubling in a lot of species.

Keywords: Colchicine; Polyploidy plant; Allopolyploids; Tumours

Introduction

Polyploidy plant production is frequently used in conventional plant breeding, producing polyploids fruits and vegetable used as human food for years. The most important feature of polyploidy is multiplication of genome. Allopolyploids have more than one genome whereas autopolyploid have duplication of a single genome. Different chemicals has been used of the induction of polyploidy in different plants, Colchicine is one of them [1-23]. Colchicine is an important alkaloid which along with its derivatives has many uses e.g. gene expression, gene amplification, anticancer activity and good effect on tumours. Along with such important features, it may also have adverse effect on seed germination and survival of the plant.

Following are some Tables 1-4 of different crops showing effect of colchicine on tetraploids induction:

SR. No.	Crop	Colchicine concentration/ Exposure time/Method	Response	Reference
1	Orange (Citrus sinensis)	0.05% & 0.1%, 12 & 24 hours, *In vitro*	Double number of chromosomes	Wu & Mooney [23]

2	Pummelo (Citrus maxima)	0.1% & 0.05%, 4, 8, 16 & 32 hours, Indirect organogenesis	Low survival rate, canker resistant plant, double number of chromosomes	Jude, et al. 2014
3	Watermelon (Citrullus lanatus)	0.1% and 0.2%, 6, 12, 18, 24 hours, *In Vivo*	Polyploidy induction, Low germination and High mortality rate	Lower and Johnson [17]
		0.2%,0.4%and 0.6%, 3 days, *In vitro*	High chlorophyll content, change in morphology of fruit and plant, high mortality, flow Cytometry show high chromosome number	Jaskani, et al. [11]
		0.2, 0.4, 0.6 %, 3 days, *In vitro*	Colchicine induced tetraploids have 10-12 chloroplast per guard cell and diploids have 5-7. Tetraploids have dark and thick leaves.	Jaskani et al. [12]
4	Pear (Pyrus communis)	0.01% and 0.1%, 1, 2, 4 and 8, *In vitro*	Tetraploids and Mixoploids induction, large stomatal size	Kadota, et al. [16]
5	Grapevine (Vitis vinifera)	0, 0.1, 0.2, 0.4 %, 24 hours, *In vitro*	Colchicine has adverse effect on germination of somatic embryo and low survival rate. Tetraploids and triploids was examined in 0.2 and 0.4% colchicine solution.	Acanda, et al. [13]
6	Tangerine citrus (Citrus reticulate)	0.2, 0.4, 0.8%, 12, 24 hours, *In vitro*	Colchicine have negative effect on germination of treated seeds. Stomatal size was highest in colchicine treated seeds .	Surson, et al. [22]

Table 1: Colchicine induced mutations in fruit crops.

SR. No.	Crop	Colchicine concentration/ Exposure time/Method	Response	Reference
1	Radish (Raphanus sativus)	30, 60, 120 mg/l, 5, 10, 15, 20 & 25 days, *In vitro*	Reduced regeneration ability of buds and explant; tetraploids induction; low germination and low survival; low yield of tetraploids	Manawadu, et al. [18]
2	Tomato (Solanum lycopersicum)	8mm, 96 Hours, *In vitro*	High mortality in seedlings with low induction; Low concentration with longer exposure time was recommended	Praca, et al. [20]
3	Onion (Allium cepa)	50 µM, 24 and 72 hours,	Colchicine have least chromosome doubling activity as compared to other mitotic inhibiter (trifluralin, oryzalin and amprophos-methyl)	Grzebelus and Adela [15]
4	Spinach (Spinacia oleracea)	1,5, 10 mg/L, 16, 24, 32 hours, *In vivo*	Colchicine have adverse effect on germination and survival. Chromosome doubling was identified by Flow Cytometry	Roughani, et al. [19]
5	Ginger (Zingiber officinale)	0.5, 2%, 2 hours, Applied on shoot tips	Tetraploids have large rhizome size, knob weight, thick shoot and high fiber content	Smith, et al. [21]
6	Wild potato (Solanum commersonii)	3.5, 5.0 and 6.5mM, 72 hours, *In vivo*	Colchicine have negative effect on germination and survival. Increase in chromosomal number was explained by Gigas effect	Gracielle, et al. [14]

7	Cucumber (Cucumis sativus)	250, 500, 550, 1500 mg/L, 18, 38hours, *In vitro*	Higher conc. Of colchicine have adverse effect on viability of explant Trifluralin and oryzalin were more effective in chromosome doubling rather than colchicine	Hamed, et al.
		0.1%, 24, 48 hours, *In vitro*	Tetraploids have broader leaf area twice than haploids. Haploids have elongated leaves while tetraploids have dentate leaves There was clear difference in flower morphology of tetraploids and haploids	Vesselina, et al.
8	Chinese kale (Brassica oleracea-Aboglabra group)	0.1, 0.5, 0.25 1 and 2%, *Ex vitro*	Large stomatal size, broader leaf	Teerarak, et al. [10]

Table 2: Colchicine induced mutations in vegetable crops.

SR. No.	Crop	Colchicine concentration/ Exposure time/Method	Response	Reference
1	**Marigold (Tagetes erecta)**	0.001%, 0.01% & 0.05%, 12 hours	Maximum shoot number with reduced length; slow growth rate; low survival	Sajjad *et al.,* 2013
2	Ocimum (ocimum basilicum)	0.05%, 0.1%, 0.2%, 0.5% and 0.75%, 6, 12, 24 and 36 hours, Seed treatment	Large and dark leaf, large size pollen grains, dark color leaves, large stomatal length and width and double number of chloroplast in tetraploids as compared to diploid	Omidbaigi *et al*. (2010)
3	**Huang qi *(Astragalus membranaceus)***	0.2%, 36 hours, In vitro	Large leaf size, large stomatal size, mixoploids induction	Chen *et al.* (2006)
4	**Grass**	0.01%, 28 hours, In vitro	Doubling of chromosomes, change cytological traits	Pinheiro *et al*. (2000)

Table 3: Colchicine induced mutations in flower crops.

SR. No.	Crop	Colchicine concentration/ Exposure time/ Method	Response	Reference
1	Ashwagandha (Withania somnifera)	0.5%, 3, 6, 8 hours, *In vitro*	Stomatal density decreases with in stomatal size in colchicine induced tetraploids.	Vidya, et al. [5]
2	Indian sarsaparilla (Hemidesmus indica)	0.5,1 ,2 and 5 mg/L, 16 and 8 hours, *In vitro*	Colchicine have more effect on shoots as compared to roots nodal explants. Survival of nodal explant was higher in solid medium as compared to liquid medium but tetraploids induction was high in liquid medium.	Nagahatenna, et al. [3]

3	Jujuba (Zizyphus jujuba)	0.01% 0.03% 0.1% and 0.3%, 24, 48, 72 and 96 hours, *In vitro*	Large stomatal size, double number of chloroplast in guard cells, change in morphology, doubling of chromosome number	Gu, et al. [4]
4	Mopane (Colophospermum mopane)	0.05% , 0.1% and 1%, Soaking seeds	Chimeras formation, low survival percentage, high mortality, slow growth rate, large lateral branches with smaller leaflets	Rubuluza, et al. [1]
5	Oil palm (Elaeis guineensis)	2.5 mM to 10.0mM, 6 to 48 hours, *In vitro*	Tetraploids and Mixoploids induction, change in genome, change in stomatal index	Madon, et al. [2]

Table 4: Colchicine induced mutations in medicinal plants.

Conclusion

Application of colchicine on different crops reported mutation in different crops in the form of chromosomal doubling. Most effective method is *in vitro* and with low concentration of colchicine. High concentration of colchicine with longer exposure time may adversely affect the survival rate of crop. Morphological changes such larger leaf size, larger flower size more chloroplast per guard cell also confirmed the induction of polyploidy.

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