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RESEARCH PAPER

Effect of mutagenic treatments on development of mutants in turmeric cv. Prathibha (*Curcuma longa* L.)

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Abstract : The present experiment was carried out during *Kharif*, 2016-2017 at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem to assess the impact of mutagens on mutagenicity like Mutation frequency on M_1 population basis, Mutagenic effectiveness, Mutagenic efficiency and Frequency of albino, xantha and chlorina mutants in turmeric. The experiment was laid out in factorial randomized block design and replicated thrice under open field conditions. Rhizomes are treated with gamma rays (25 Gy and 50 Gy) and EMS (250 ppm, 500 ppm and 1000 ppm) along with control. Maximum mutagenic frequency, effectiveness and efficiency was observed in25 Gy, 250 ppm EMS and combination of 25 Gy + 250 ppm EMS and minimum was recorded in 50 Gy gamma rays, 1000 ppm EMS and combination both 50 Gy + 500 ppm EMS and 50 Gy + 1000 ppm EMS .

Key Words : Mutagenicity, Mutagenic effectiveness, Gamma rays, EMS, Turmeric

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INTRODUCTION

Turmeric (*Curcuma longa* L.) is one of the important spices grown in India, which plays an important role in the national economy. It is a member of the family, Zingiberaceae and originated from South East Asia. States like Telangana, Andhra Pradesh, Orissa, Kerala, Tamil Nadu, Karnataka, Maharashtra and West Bengal are in the forefront in turmeric cultivation and research. Cultivated turmeric, *Curcuma longa* L. is considered to be a triploid with a somatic chromosome number of sixty three (2n= 3x=63) (dibasic amphidipliod) and sets seeds rarely. Since, turmeric is an asexually propagated crop with no regular seed production, clonal selection is the major mode of crop improvement. The first step in the crop improvement of this clonally propagated crop is to exploit the variability existing among the land races, create more variability through mutation and somaclonal variation. The use of mutagens for inducing variability assumes greater significance. In vegetatively propagated crops with reproductive sterility (such as turmeric), mutation breeding this is very important tool in crop improvement (Broertjes and Van Harten, 1988). An attempt was therefore made to calculate the mutagenicity like Mutation frequency on M_1 population basis,

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Mutagenic effectiveness, Mutagenic efficiency and Frequency of albino, xantha and chlorina mutants in turmeric by gamma rays and EMS.

MATERIAL AND METHODS

The present investigation was carried out during *Kharif*, 2016-2017 at College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, and Andhra Pradesh. The experiment was laid out in Factorial Randomized Block Design and replicated thrice under open field condition. Healthy and disease free fingers with well developed buds were selected for planting. Prathibha variety is used as a planting material. Rhizomes are treated with gamma rays (25 Gy and 50 Gy) and EMS (250 ppm, 500 ppm and 1000 ppm) along with control. Treated rhizomes are planted in protrays. After one month, seedlings are transplanted to main field. After planting basal dose of NPK fertilizers were applied at the rate of 150:125:250 Kg/ha. The nitrogenous and potash fertilizers were applied at three equal doses at 45, 90 and 135 days after planting in the form of urea, MOP and phosphate fertilizer was applied in the form of SSP. The field was irrigated before planting. Light irrigation was given on the third day after transplanting. Therefore, irrigation was given at weekly intervals depending on weather and soil conditions. Five plants in each treatment were tagged randomly for recording observations and mean values were subjected to statistical scrutiny. The data was analyzed using the procedure outlined by Panse and Sukhatme (1967).

Mutation frequency on M_1 population:

Frequency of chlorophyll and morphological mutations were estimated by the following formula:

$$\text{Mutation frequency (\%)} \frac{\text{Number of mutants}}{\text{Total number of plants scored}} \text{ x 100}$$

Mutagenic effectiveness and efficiency:

The effectiveness and efficiency of the mutagen in inducing chlorophyll and viable mutations were estimated adopting the formulae suggested by Konzak (1957) and expressed in percentage.

Physical mutagen :

$$\text{Mutagenic effectiveness (Physical mutagen)} = \frac{\text{Mutation rate}}{\text{Dose of mutagen (Gy)}} \text{x100}$$

Chemical mutagen :

$$\text{Mutagenic effectiveness} = \frac{\text{Number of mutants}}{\text{(Conc. of mutagenin \%) x (Time of treatment in hours)}} \text{x100}$$

Combination :

$$\text{Mutagenic effectiveness (\%)} = \frac{\text{Mutation rate}}{\text{(Dose of physical mutagen (Gy) x (Conc. of chemical mutagen) (\%) x Time(h)}} \text{x100}$$

$$\text{Mutagenic efficiency (\%)} = \frac{\text{Mutation rate (Mf)}}{\text{Per cent injury (I) / Per cent lethality (L) / Per cent sterility (S)/ Per cent mitotic aberrations (M)}} \text{x100}$$

where,

M= Chlorophyll or viable mutations per 100 vM_1 plants.

L= Per cent of lethality (*i.e*)., percentage reduction in survival of seedlings.

I = Percentage of injury.

Mutation spectrum:

The spectrum of chlorophyll and morphological mutations was recorded in M_1V_1 Chlorophyll mutants were classified as below as suggested by Gustafsson (1974):

Albino: Leaves are white, lack carotenoids and chlorophyll and generally have small plastids.

Xantha: Leaves with little or no chlorophyll but have carotenoid pigmentation and are yellow.

Alboviridis: Leaves have different rate of plastid development at the base and tips of each leaf and exhibit different colours in these areas.

Viridis: They are light green in colour.

Tigrina: Exhibit transverse stripes along the leaf with alternating narrow bands of green and yellow or brown where pigment destruction has occurred.

Striata: They have yellow or white longitudinal bands alternating with green colour.

Maculate: Have spots where chlorophyll and / or carotene have been destroyed.

Morphological mutants were classified as dwarfs,

mutants with twisted leaves, split leaves, joint leaves and crinkled leaves.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Mutation frequency on M_1 population basis:

The frequency and spectrum of chlorophyll mutants were scored to assess the mutability due to the mutagens.

Among the gamma ray treated plants, higher mutation frequency (22.50 %) was observed with 25 Gy gamma rays followed by 50 Gy gamma rays (12.50%). As regards to EMS concentration, higher mutation frequency (7.50%) was recorded in both 250 ppm EMS concentration and 500 ppm EMS concentration followed by 1000 ppm EMS concentration (2.50%) (Table 1).

Among the treatment combinations, maximum mutation frequency (20.00%) was observed in 25 Gy gamma rays + 250 ppm EMS concentration followed by 25 Gy gamma rays + 500 ppm EMS concentration (17.50 %) and minimum mutation frequency (5.00%) was recorded in both 50 Gy gamma rays + 500 ppm EMS concentration and 50 Gy gamma rays + 1000 ppm EMS concentration.

Mutagenic effectiveness:

Among the gamma rays treated plants, higher mutagenic effectiveness (0.009) was observed in 25 Gy gamma rays followed by 50 Gy gamma rays (0.002). As regards to EMS concentration, higher mutagenic effectiveness (3.940) was recorded in both 250 ppm EMS concentration and 500 ppm EMS concentration (1.970) followed by 1000 ppm EMS concentration (0.330) (Table 2).

Among the treatment combinations, maximum mutagenic effectiveness (0.420) was recorded in 25 Gy gamma rays + 250 ppm EMS concentration followed by 25 Gy gamma rays + 500 ppm EMS concentration (0.060) and minimum mutagenic effectiveness (0.010) was recorded in 50 Gy gamma rays + 1000 ppm EMS concentration.

Mutagenic efficiency:

Among the gamma ray treated plants, higher mutagenic efficiency (0.012) was observed in 25 Gy gamma rays followed by 50 Gy gamma rays (0.006). Among the EMS concentrations, higher mutagenic efficiency (0.004) was recorded in both 250 ppm EMS concentration and 500 ppmEMS concentration (1.970) followed by 1000 ppm EMS concentration (0.330) (Table 2).

Among the treatment combinations, highest mutagenic efficiency (0.010) was observed in 25 Gy gamma rays + 250 ppm EMS concentration followed by 25 Gy gamma rays + 500 ppm EMS concentration (0.008) and the lowest mutagenic efficiency (0.002) was recorded in 50 Gy gamma rays + 1000 ppm EMS concentration.

Frequency of albino, xantha and chlorina mutants:

The spectrum of chlorophyll mutants showed three types *viz*., albino, xantha and chlorina. But only chlorina

Table 1 : Mutation frequency on M_1 population basis

Treatments	Total M_1 plants studied	Total number of viable mutants	Mutation frequency (%)
0 Gy +0 ppm EMS	40	0	0.00
0 Gy + 250 ppm EMS	40	3	7.50
0 Gy + 500 ppm EMS	40	3	7.50
0 Gy +1000 ppm EMS	40	1	2.50
25 Gy +0 ppm EMS	40	9	22.5
25 Gy +250 ppm EMS	40	8	20.0
25 Gy +500 ppm EMS	40	7	17.5
25 Gy +1000 ppm EMS	40	6	15.0
50 Gy +0 ppm EMS	40	5	12.5
50 Gy +250 ppm EMS	40	5	12.5
50 Gy +500 ppm EMS	40	2	5.00
50 Gy +1000 ppm EMS	40	2	5.00

mutants were observed.

Among the gamma rays treatments, higher number of chlorina mutants was observed in 25 Gy gamma rays (9) followed by 50 Gy gamma rays (5). As regards to EMS, higher number of chlorina mutants (3) was observed in both 250 ppm EMS concentration and 500 ppm EMS concentration followed by 1000 ppm EMS concentration (Table 3).

Among treatment combinations, higher chlorina mutants (8) was recorded in 25 Gy gamma rays + 250 ppm EMS concentration followed by 25 Gy gamma rays + 500 ppm EMS concentration (7) and lower number of chlorina mutants (2) was recorded in 50 Gy gamma rays + 1000 ppm EMS concentration.

In the present study, there were differences in the frequency of chlorophyll mutations due to doses and concentrations of gamma rays and EMS. The occurrence of chlorophyll chimera in the present investigation could be attributed to chromosomal aberrations, change in the route of auxin synthesis, disruption of mineral metabolism or accumulation of free amino acids. Nuclear and/or plastid mutations were thought to cause variegations in leaves (Kirk and Bassett, 1967). Laxmi *et al.* (1980) considered that chimera formation in leaves as a result of gamma irradiation might be due to the multicellular nature of the tissues treated. Leaf variegation due to gamma irradiation had been documented in *Canna* (Nakornthap, 1965). Raju *et al*. (1980) obtained such a phenomenon in ginger. Variation in leaf shape and colour had been observed in *Costus* by Gupta *et al.* (1982). In

Table 2 : Mutagenic effectiveness and efficiency of chlorophyll mutation (%) of turmeric cv. Prathibha

Treatments	Lethality	Mutation rate	Mutagenic effectiveness	Mutagenic efficiency
0 Gy +0 ppm EMS	16.87	0.000	0.00	0.000
0 Gy + 250 ppm EMS	17.77	0.075	3.940	0.004
0 Gy + 500 ppm EMS	18.40	0.075	1.970	0.004
0 Gy +1000 ppm EMS	19.64	0.025	0.330	0.001
25 Gy +0 ppm EMS	17.34	0.225	0.009	0.012
25 Gy +250 ppm EMS	18.44	0.200	0.420	0.010
25 Gy +500 ppm EMS	20.10	0.175	0.180	0.008
25 Gy +1000 ppm EMS	21.40	0.150	0.060	0.007
50 Gy +0 ppm EMS	18.14	0.125	0.002	0.006
50 Gy +250 ppm EMS	19.27	0.125	0.132	0.006
50 Gy +500 ppm EMS	21.54	0.050	0.020	0.002
50 Gy +1000 ppm EMS	22.04	0.050	0.010	0.002

Table 3 : Types of chlorophyll mutants of turmeric cv. Prathibha

Treatments	Total number of chlorophyll mutants	Chlorophyll mutants		
		Albino	Xantha	Chlorine
0 Gy +0 ppm EMS	0	0	0	0
0 Gy + 250 ppm EMS	3	0	0	3
0 Gy + 500 ppm EMS	3	0	0	3
0 Gy +1000 ppm EMS	1	0	0	1
25 Gy +0 ppm EMS	9	0	0	9
25 Gy +250 ppm EMS	8	0	0	8
25 Gy +500 ppm EMS	7	0	0	7
25 Gy +1000 ppm EMS	6	0	0	6
50 Gy +0 ppm EMS	5	0	0	5
50 Gy +250 ppm EMS	5	0	0	5
50 Gy +500 ppm EMS	2	0	0	2
50 Gy +1000 ppm EMS	2	0	0	2

ginger, Giridharan (1984) recorded yellow streaks as a result of radiation treatments in the cultivars Rio-de-Janeiro and Maran.

The concept of mutagenic effectiveness and efficiency was reported by Konzak *et al.* (1965). The efficiency is considered as an estimate of biological effects induced *via* lethality, injury and sterility, while the effectiveness is a measure of gene mutations in relation to dose and concentration. Hence to get high efficiency, the mutagenic effects must surpass other effects in the cell, such as chromosomal aberrations and other toxic effects, which results in damages. Doll and Sandfaer (1969) found a close relationship between chlorophyll mutations and viable mutations. In the present investigation, the increase in lethality can be attributed to increase in the dose and concentration levels. High efficiency of gamma rays at lower doses may be due to the enhanced activity perhaps as a result of gene interactions arising due to the positive effect of mutated genes. Further, a mutagen with localized action influencing the ontogenic physiological development of the selected material can alter its efficiency and effectiveness as postulated by Mikaelson (1968) and Swaminathan (1965) in turmeric.

Changing the spectrum of mutations in a predictable manner and thereby achieving directed mutagenesis is an important goal of current mutation research (Auerbach, 1967). Sato (1966) expressed that a close relationship exists between the chlorophyll and viable mutations. Different spectra were known to be induced by mutagens in different varieties of crop plants (Amato *et al*., 1962, Gustafsson, 1963 and Heslot, 1964).

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