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Research Article

Induction of mutations for plant height and inheritance of dwarf mutant in groundnut (*Arachis hypogaea* L.) through gamma ray irradiation

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Abstract:
Gamma ray induced mutagenesis of groundnut cultitvar TAG 24 evolved true breeding several mutants affecting various morphological traits. Among them, 16 mutants were dwarf and three were tall. Plant height was reduced by 24.5% to 41.0% in dwarf mutants and increased by 13.1 to 30.6% in tall mutants. Progenies from an interesting dwarf mutant consistently segregated into dwarf, extreme dwarf and parental types. From the hybridization between mutant and its parent, it was concluded that dwarf mutation was due to monogenic incomplete dominance.

Key words:
Groundnut, Gamma rays, Dwarf mutant, Tall mutant, Incomplete dominance

Introduction

Wide spectrum of genetic variability has been induced in groundnut (*Arachis hypogaea* L.) using both physical and chemical mutagens in order to utilize it in groundnut improvement and inheritance studies (Ashri, 1970; Patil, 1966; Gowda *et al*., 1996). Earlier reports in groundnut showed that several mutations affected qualitative and quantitative traits such as leaf size, shape and colour, plant height, plant habit, flower colour, pod and seed traits (Patil, 1966; Ashri, 1970; Patil and Mouli, 1984; Desale *et al*., 1986; Dwivedi et al., 1996; Gowda *et al*., 1996). Among them, mutants with reduced plant height, small leaflets and reduced chlorophyll content were common. Groundnut dwarf mutants were induced using X rays (Patil, 1966), gamma rays (Patil and Mouli, 1978), laser (Bozhan *et al*., 1997), diethyl sulfate (Ashri, 1970), ethyl methane sulfonate (Gowda *et al*., 1996), ethidium bromide (Levy and Ashri, 1975) and colchicine (Tiwari and Khanorkar, 1984). In the present study, induction of dwarf and tall mutants using gamma rays and inheritance of unique dwarf mutant are reported.

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Seeds of groundnut cultivar TAG 24 (Patil *et al*., 1995) were treated with 150, 250 and 350 Gy gamma rays during rainy season 2000 and the M_2 population was grown at the Experimental Gamma Field Facilities Section, Bhabha Atomic Research Centre, Mumbai. Among the spectrum of mutants for various traits induced, mutations for plant height involving 16 for dwarf and three for tall height were isolated. Their true breeding nature was confirmed by studying the M_3 and subsequent generations. Of the 16 dwarf mutants, five were obtained through 150 and 11 through 250 Gy. In tall mutants, one each was induced from 150, 250 and 350 Gy treatments.

Based on the observations on plant height from two rainy (2002, 2003) and three summer (2002, 2003, 2004) seasons from mutants and parent, the mean plant height in TAG 24 ranged from 36.0 to 41.2 cm in summer and 52.2 to 56.8 cm in rainy season (Table 1). A significant reduction in plant height was noted among the dwarf mutants which ranged from 21.0 to 34.0 cm in summer and 28.5 to 45.5 cm in rainy season. Overall mean reduction was from 24.5% in the mutant TGM 42 to 41.0% in TGM 8 as compared to TAG 24. Similarly, plant height was increased significantly among the tall mutants, where the height ranged from 39.5 to 49.1 cm in summer and 60.3 to 74.9 cm in rainy season. The highest mean increase of 30.6% was noted in the mutant TGM 59.

Among the dwarf mutants, TGM 36 was unique with a mutation frequency of 0.0087%, based on total number of M_2 plants. This mutant was always segregated into three phenotypes, i) parental, ii) dwarf and iii) extreme dwarf types when advanced as plant to row progeny in the subsequent generations (Fig. 1). In M_3 to M_7 generations, parental and extreme dwarf types bred true in the next generations, while the dwarf continued to segregate into 1 parental: 2 dwarf: 1 extreme dwarf types. Plant height of the parental type was at par with TAG 24 and dwarf and extreme dwarf genotypes had only 38.7% and 20.4% height of TAG 24, respectively (Table 2). Although, there was no reduction in number of internodes on main axes in the dwarf phenotypes, the internodal length was considerably reduced. The mutant is being maintained by raising progenies from dwarf types.

In order to study the inheritance of dwarf mutation, all the three genotypes of TGM 36 were crossed with parent TAG 24. Hybrid seeds from TAG 24 X parental type and its reciprocal cross were obtained. With a great difficulty, five F_1 seeds from TAG 24 X dwarf type only were obtained, of which only three seeds germinated; one was dwarf and two were parental types and were advanced to F_2 and F_3 generations. Even with greater crossing efforts, hybrid seeds could not be formed in the cross involving TAG 24 and extreme dwarf type. In the F_2 from TAG 24 X dwarf type, plants segregated in a ratio of 1 parental: 2 dwarf: 1 extreme dwarf types (Table 3). Progenies in F_3 generation fitted well to expected ratio of 1 (all parental types): 2 (1 parental: 2 dwarf: 1 extreme dwarf types): 1 (all extreme dwarf types). In both F_1 and F_2 generations, all the plants from the cross between TAG 24 and parental type were parental type. Both phenotypic and genotypic segregations revealed that dwarf trait shows incomplete dominance.

Branch and Hammons (1983) reported a natural miniature phenotype in groundnut cultivar, Tennesse Red, which segregated into micro (extreme reduction in stems and leaves), mini (reduction in both vegetative and reproductive organs) and normal plants leading to partial dominance for the micro type as observed in the present study. Similarly, rice dwarf mutant also showed incomplete dominance by having segregation into wild, semi-dwarf and extreme dwarf types (Sunohara and Kitano, 2003). However, another groundnut dwarf mutant segregated into diminutive, intermediate and normal plant height for initial 5-6 weeks (Ashri, 1970). Later, more and more diminutive plants changed to mixed phenotype having normal and diminutive branches. Diminutive, mixed and intermediate plants segregated again into four types, while normal plants bred true in the next generation. This dwarf mutant was lethal in homozygous condition; that the diminutive, mixed and intermediate were having different phenotypic expressions of heterozygous condition; and that the normal were homozygous normal. Hence, this dwarf mutant allele was a dominant factor with recessive lethal effect. Thus, TGM 36 dwarf mutant allele was different from this dwarf mutant by virtue of its recessive lethality.

References:

Ashri A. 1970. A dominant mutation with variable penetrance and expressivity induced by diethyl sulfate in peanuts, *Arachis hypogaea* L. Mutation Res., 9: 473-480.

Bozhan H., Yang L.C. and Jiezhen F. 1997. Biological effects of laser and ^{60}Co gamma rays on M_1 plants of groundnut (*Arachis hypogaea* L.). Oil Crops of China. 19: 12-14.

Branch W.D. and Hammons R.O. 1983. Inheritance of a micro phenotype in peanut. Crop Sci. 23: 1045-1046

Desale S.C., Bhapkar D.G. and Thombre M.V. 1986. Inheritance of faint orange flower colour in groundnut. J. Oilseeds Res. 3: 135-136.

Dwivedi S.L., Singh A.K. and Nigam S.N. 1996. Unstable white flower color in groundnut (*Arachis hypogaea* L.). J. Hered. 87: 247-248.

Gowda M.V.C., Nadaf H.L.and Sheshagiri R. 1996. The role of mutation in intraspecific differentiation of groundnut (*Arachis hypogaea* L.). Euphytica. 90: 105-113.

Levy A. and Ashri A. 1975. Ethidium bromide – an efficient mutagen in higher plants. Mutation Res. 28: 397-404.

Patil S.H. 1966. Mutations induced in groundnut by X-rays. Indian J. Genet., 26A: 334-348.

Patil S.H. and Mouli C. 1978. Radiation induced bunchy top mutant in groundnut. Current Sci. 47: 22-23.

Patil S.H. and Mouli C. 1984. Preferential segregation of two allelic mutations for small leaf character in groundnut. Theor. Appl. Genet. 67: 327-332.

Patil, S.H., Kale, D.M., Deshmukh, S.N., Fulzele, G.R. and Weginwar, B.G. 1995. Semi-dwarf, early maturing and high yielding new groundnut variety, TAG-24. J. Oilseed Res. 12: 254-257.

Sunohara H. and Kitano H. 2003. New dwarf mutant controlled by a dominant gene, *Twisted dwarf1*. Rice Genet. Newsl. 20: 20-22

Tiwari S.P. and Khanorkar S.M. 1984. Colchicine induced true breeding miniature mutant in groundnut. Current Sci. 53: 1262-1263.

Table 1: Plant height (cm) in tall and dwarf mutants of TAG 24

Mutant	M_4	M_5	M_6	M_7	M_8	Mean		Grand Mean	% change in mutants over TAG 24
	Summer	Rainy	Summer	Rainy	Summer	Summer	Rainy		
Dwarf mutants									
TGM 1	23.9*	32.3*	29.5*	31.4*	24.5*	26.0	31.8	28.3	-36.6
TGM 2	27.2*	36.5*	28.0*	43.1*	24.0*	26.4	39.8	31.8	-28.9
TGM 3	26.5*	34.3*	28.5*	41.0*	26.5*	27.1	37.6	31.4	-29.7
TGM 4	26.3*	40.1*	27.0*	38.7*	32.5*	28.6	39.4	32.9	-26.3
TGM 5	32.5*	35.0*	27.0*	39.6*	34.0	31.2	37.3	33.6	-24.7
TGM 8	27.0*	29.2*	26.0*	28.5*	21.0*	24.7	28.8	26.3	-41.0
TGM 10	28.0*	35.1*	29.5*	35.6*	27.0*	28.1	35.3	31.0	-30.5
TGM 14	22.5*	34.5*	25.0*	39.4*	22.5*	23.3	37.0	28.8	-35.5
TGM 18	25.5*	38.6*	26.0*	37.7*	27.0*	26.1	38.1	31.0	-30.6
TGM 19	23.1*	34.7*	21.5*	36.0*	24.0*	22.8	35.3	27.9	-37.6
TGM 25	23.4*	30.2*	22.5*	42.6*	28.0*	24.6	36.4	29.4	-34.3
TGM 42	28.2*	45.5*	26.5*	41.4*	27.0*	27.2	43.4	33.7	-24.5
TGM 43	27.6*	34.2*	27.0*	36.7*	21.5*	25.4	35.4	29.4	-34.1
TGM 69	25.8*	35.5*	27.0*	44.6*	25.0*	26.0	40.0	31.5	-29.3
TGM 73	26.0*	37.3*	24.0*	40.5*	25.5*	25.1	38.9	30.7	-31.3
Tall mutants									
TGM 59	47.8*	74.9*	47.5*	73.4*	48.0*	47.8	74.6	58.3	30.6
TGM 85	49.1*	61.6*	39.5	60.3	42.0*	43.5	61.0	50.5	13.1
TGM 86	48.2*	65.0*	43.5*	60.9	41.5*	44.4	63.0	51.8	16.1
TAG 24 (Parent)	41.2	52.2	37.0	56.8	36.0	38.1	54.5	44.6	

* Significantly different from TAG 24 at P = 0.05

Table 2. Plant height, internode number and internodal length in groundnut dwarf mutant, TGM 36

Mutant	Plant height (cm)			Internode number			Internodal length (cm)		
	M_4 Summer	M_5 Rainy	Mean	M_4 Summer	M_5 Rainy	Mean	M_4 Summer	M_5 Rainy	Mean
Parental type	35.3	57.2	46.3	13.9	24.2	19.1	2.6	2.4	2.5
Dwarf	15.3**	21.0**	18.2**	14.9	22.2	18.6	1.1**	1.0**	1.0**
Extreme dwarf	7.8**	11.3**	9.6**	13.8	21.6	17.7	0.6**	0.5**	0.6**
TAG 24	37.2	56.8	47.0	14.4	23.7	19.1	2.6	2.4	2.5

** Significantly different from TAG 24 at P = 0.01

Table 3. Segregation of dwarf trait in groundnut mutant, TGM 36

Generation/Cross	No. of progenies	Parental type	Dwarf type	Extreme dwarf	χ^2 (1:2:1)	df	P
M_3	1	3	6	4	0.2306	2	0.75-0.90
M_4	1	4	12	6	0.5453	2	0.75-0.90
M_5	2	17	24	8	3.3264	2	0.10-0.25
M_6	17	362	--	--			
	24	115	234	97	2.538	2	0.25-0.50
	8	--	--	18			
M_7	3	19	45	20	0.4522	2	0.75-0.90
TAG 24 X Dwarf type							
F_2	1	3	14	6	1.8690	2	0.25-0.50
F_3	3	57	--	--			
	14	51	72	37	4.0500	2	0.10-0.25
	6	--	--	26			
Pooled		20	38	14	1.2221	2	0.50-0.75
TAG 24 X Parental type							
F_2	3	51	--	--			
Parental type X TAG 24							
F_2	2	28	--	--			

Fig. 1 Plant height segregation in dwarf groundnut mutant, TGM 36