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Segregation of Vegetative Trait Aberrations in Chemical Mutagen Treated Groundnut (*Arachis hypogaea* L.) Varieties

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ABSTRACT: In groundnut (*Arachis hypogaea* L.) the vegetative morphology is used to determine the crop duration, maturity index and is the backbone of taxonomic classification considering the geocarpic pegging nature of the crop. Induced mutation has proved to be very beneficial in groundnut crop. In a mutation breeding program, selection of appropriate mutagen allows production of wide spectrum of desirable mutants. The present study was conducted to study the mutagenic frequency of vegetative traits appearing in M_2 population of treated groundnut varieties and study the effect of different doses of chemical mutagens i.e ethyl methane sulfonate (EMS) and sodium azide (SA) in producing aberration in vegetative traits. The occurrence of segregants in M_2 allows to study the variation of characters present in the parent population and selection of true mutants. As most of the characters in groundnut are not linked, it alsoallowsthe use of mutants for a varietal development.A diverse range of viable mutations with altered vegetative morphological traits were isolated in the mutagenized groundnut population in M_2 generation, which may be useful in yield improvement traits. Most number of dwarf plants (147) were obtained from V_3 treated with SA (V_3N). Shift in the pattern of growth habit were observedin some mutants. Variation in leaflet number and size followed an order of $V_3>V_4>V_1>V_2$. Cuneate mutant was observed in V_1. V_4 had unique trait of leaf node pigmentation. The mutagenic frequency ranged from 0.0484 in $V_{4(\text{Total EMS})}$ to 0.5308 in $V_{3(\text{Total SA})}$. SA efficiently produced more number of mutants than EMS. In growth habit erect type was prominent mutant. In number of leaflets, pentafoliate and hexafoliate types and in leaf tip the mucronate mutant were most common type of mutation in segregating plant population. In mutation breeding experiment handling and maintaining of the field is a challenging task. Generally, the morphological mutants are not taken into consideration to estimate the mutagenic frequency and even if attempt is made only few desirable ones are recorded. Identification of a mutant was carried out with the set of groundnut descriptors to study the variations occurring and further generation screening and advancement.

Keywords: Segregation, mutagenic frequency, aberration, mutation, *Arachis.*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) belongs to Fabaceae family and is mainly grown as an annual oilseed crop. The geocarpic peg and the underground development of the pod makes it difficult to determine the maturity and pod yield of the crop. This necessitates relying on the vegetative morphology to estimate the crop duration and maturity index. Krapovickas and Gregory (1994) suggested that the vegetative growth of a plant is the backbone of its taxonomic classification. Branching pattern was used as the main character to distinguish between two subspecies of groundnut. The plant type is studied by earlier workers (Hull, 1937; Hayes, 1933; Balaiah *et al.*, 1984). The commonly growing groundnut varieties can be grouped from spreading to erect types. The spreading types are perennial in nature and indeterminate growth habit with different stages of pods growth, making them late duration types. Whereas, the erect type with annual habit and bushy growth has pods more or less maturing together thus categorized as early maturing type. The branching pattern is mostly alternate but can also vary. Stem pigmentation (reddish-purple tinge) is dominant over green stem and the intensity varies with environmental factors like amount of daylight (Patel *et al.*, 1936). Likewise, the shoot pubescence is dominant over glabrous (Badami, 1928). Hassan (1964) studied the different variations in leaf shape. Anitha *et al*. (2017) used to study the leaf characters for M_2 population in bougainvillea. Balaiah *et al*. (1984) suggested linkage involving the genes for growth, branching, shoot pigmentation and leaflet shape with 6 to 39 crossover percentage. The occurrence of segregants in M_2 allows to study the variation of characters present in the parent population and selection of true mutants. As most of the characters in groundnut are not linked, it gives a scope for using mutants to forward for a varietal development. Burghate *et al*. (2017) studied the spectrum and frequency of plant type, leaf modifications and growth habit in EMS induced groundnut variety TAG 24 whereas Raina and Khan (2020) studied the same in cowpea using sodium azide. Upadhyaya *et al*. (2002) used 14 ICRISAT groundnut descriptors to form a core collection in ICRISAT genebank. Yol *et al*. (2018) used 5 qualitative traits to evaluate 256 groundnut genotypes from 5 countries to develop parental genotypes for breeding program. The qualitative traits are controlled by fewer genes and can be important in directly increasing the yield. In plant type erect and dwarf mutants are preferred over long and spreading type and this ensures proper relocation of food in storing than the vegetative growth of the plant. Increased plant biomass also is important for fodder purposes and growth habit characters are responsible for the trait. Leaf colour modification can ensure drought tolerance in groundnut as dark and bluish green morphology is a preferred morphology. Genetic variability in groundnut can be induced successfully through mutation with genetic stability of other characters.

MATERIALS AND METHODS

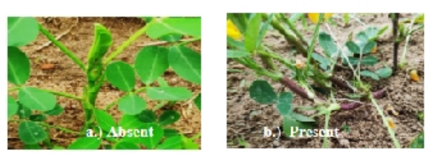
The present study was conducted to estimate the mutagenic frequency of ten vegetative traits of groundnut crop *viz.*, height, maturity, branching pattern, growth habit, shoot pubescence, stem pigmentation, leaflet number, leaf shape, leaflet margin and leaflet tip as described in IPGRI-ICRISAT descriptors (Fig. 1) in the viable M_2 segregating population of three different doses of chemical mutagens EMS (E_1, E_2 and E_3) and SA (N_1, N_2 and N_3) *viz.*, 0.2%, 0.3% and 0.4% respectively in four groundnut varieties *viz.*, Smruti (V_1), Devi (V_2), ICGV 7220 (V_3) and ICGV 2266(V_4) with a total of twenty four treatments and four controls. The tables and analysis are done with the help of Microsoft Office Excel. The mutation frequency for individual treatment was calculated as per the formula given below:

$$\text{Mutation frequency (\%)} = \frac{\text{Number of mutant plants}}{\text{Number of total plants scored}} \times 100$$

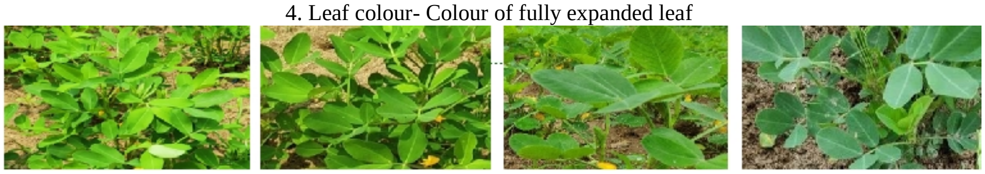
1. Growth habit

2. Shoot pubescence (Observed on the main axis)

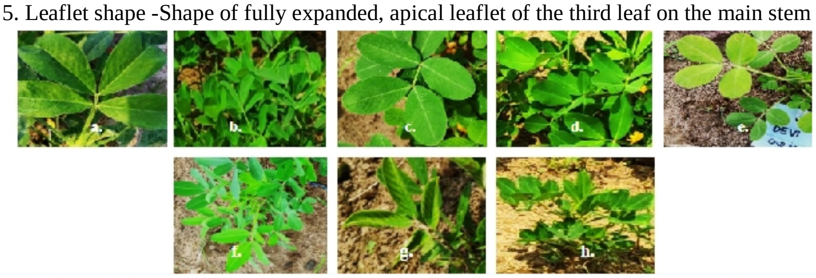
3. Stem pigmentation



4. Leaf colour- Colour of fully expanded leaf



5. Leaflet shape -Shape of fully expanded, apical leaflet of the third leaf on the main stem



5 a.) Cuneate b.) Narrow-elliptic c.) Wide elliptic d.) Obovate e.) Orbicular f.) Oblong g.) Oblong-lanceolate h.) Lanceolate

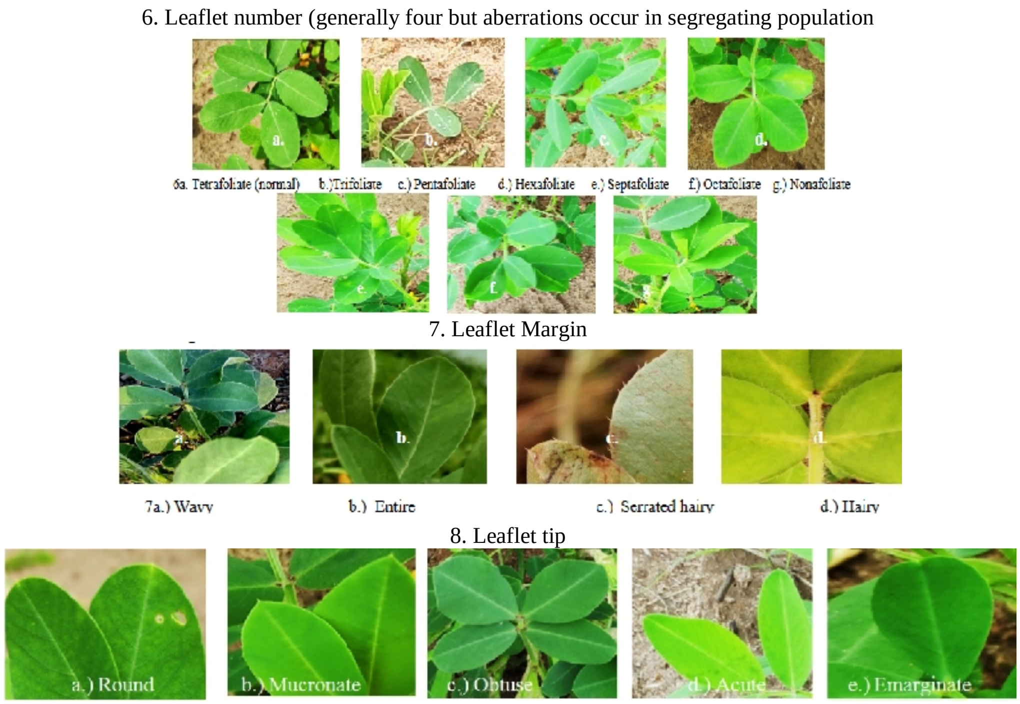


Fig. 1. Morphological variations observed in segregating M_2 population for vegetative traits in groundnut varieties.

RESULT AND DISCUSSIONS

Plant height is one of the important trait while considering selection of a mutant. In the present study, highest number of tall plants (170) were obtained in V_1 genotype treated with different doses of EMS whereas genotype V_3 treated with SA (V_3N) recorded most number of dwarf (147) plants. Dwarf mutants can be directly used for varietal development as done by Badigannavar and Mondal (2010) from mutagen treated TAG 24 groundnut variety and most of the groundnut varieties released by ICRISAT. Raina and Khan (2020) used different doses of SA to induce mutants for growth habit, plant height and other morphological characters in two varieties of cowpea. V_2 was an early maturing and V_4 a late maturing variety but mutagenic treatments of all varieties produced early maturing types in V_1 (8), V_3 (9) and V_4 (8) as well as late maturing types in V_1 (30) and V_2 (11) which improves seed dormancy in V_2. Branching pattern is one of the most important character to distinguish the subspecies in groundnut (Krapovickas and Gregory 1994). The trait plays an important role in pod yield as suggested by Wells and Isleib (2001); Kumar *et al*. (2010). Branching pattern in groundnut is mostly alternate but some may show sequential (Burghate *et al*., 2017), but some irregular types were seen in varieties V_1N_2 (63), V_4E_2 (2) and V_4N_2 (52). Growth habit pattern saw a shift from decumbent to erect type in V_1(181) (in V_1E_1, V_1E_2, V_1E_3, V_1N_1 and V_1N_3) and V_4(251) whereas a shift from erect to decumbent type in V_2 (49) and V_3 (260) mostly with SA with highest in V_3N_3 (106). All the four varieties had varied degrees of shoot pubescence however few mutants were glabrous like V_1E_1 (73), V_1N_2 (68) and V_2N_3 (126) whereas very hairy type in V_3E_2 (7) and V_3E_3 (16). Stem pigmentation is dominant over absence of it. V_1 and V_4 are pigmented types but V_1N_3 was devoid of pigment in 43 plants and V_2 and V_3 were varieties with green stem but V_2N_3, V_3E_1 and V_3N_1 had few pigmented plants. V_4 had unique pigment at base of the leaflets. There was not any significant relation between the growth habit or hairiness or stem pigmentation as discussed by (Olasan *et al*., 2018). In groundnut, tetrafoliate leaflet is a general feature but mutation tends to change it due to the anomaly the cell is exposed to during division. V_1E_1, V_4N_1 and V_4N_2 showed some trifoliate leaves. Pentafoliate and hexafoliate leaflets were recorded in almost all varietal treatments. Heptafoliate type was observed in V_3N_2 and V_3N_3, octafoliate type was observed in V_3N_1 and V_3N_2 and nonafoliate leaflets was exclusively found in V_3N_1. Little leaf mutants were seen in V_3N_1 and V_4N_3 and broad leaved mutants in V_3N_1. Leaf shape was different for different varieties however some evident changes in shape was visible in few cases. Cuneate mutant was observed in V_1E_1 and V_1N_2 whereas orbicular type was seen in V_2 and lanceolate leaf was observed in V_3N_1 and V_3N_3. Mondal and Badiganavvar (2012) used narrow leaved mutant from EMS treated Trombay groundnut to develop variety. V_1 and V_2 had entire leaf margins whereas V_3 and V_4 were hairy and V_4 was serrated type. In leaflet tip, rounded and obtuse were common but mucronate, emarginate and acute type variations were also observed. The detailed values are given in Table 1. The frequency of mutation ranged from 0.0484 in $V_{4(\text{Total EMS})}$ to 0.5308 in $V_{3(\text{Total SA})}$ with the cumulative mutation to be 2.667 *per cent* in total population. The mutagenic frequency of occurring mutants saw decreasing order of V_3N (0.5308) > V_4N (0.4927) > V_1N (0.4615) > V_2N (0.4539) > V_1E (0.4460) > V_3E (0.1534) > V_2E (0.1129) > V_4E (0.0484). The frequency of each mutant occurring in the entire M_2 population and frequency of mutants occurring for individual treatments is illustrated in Fig. 2 and 3 respectively.

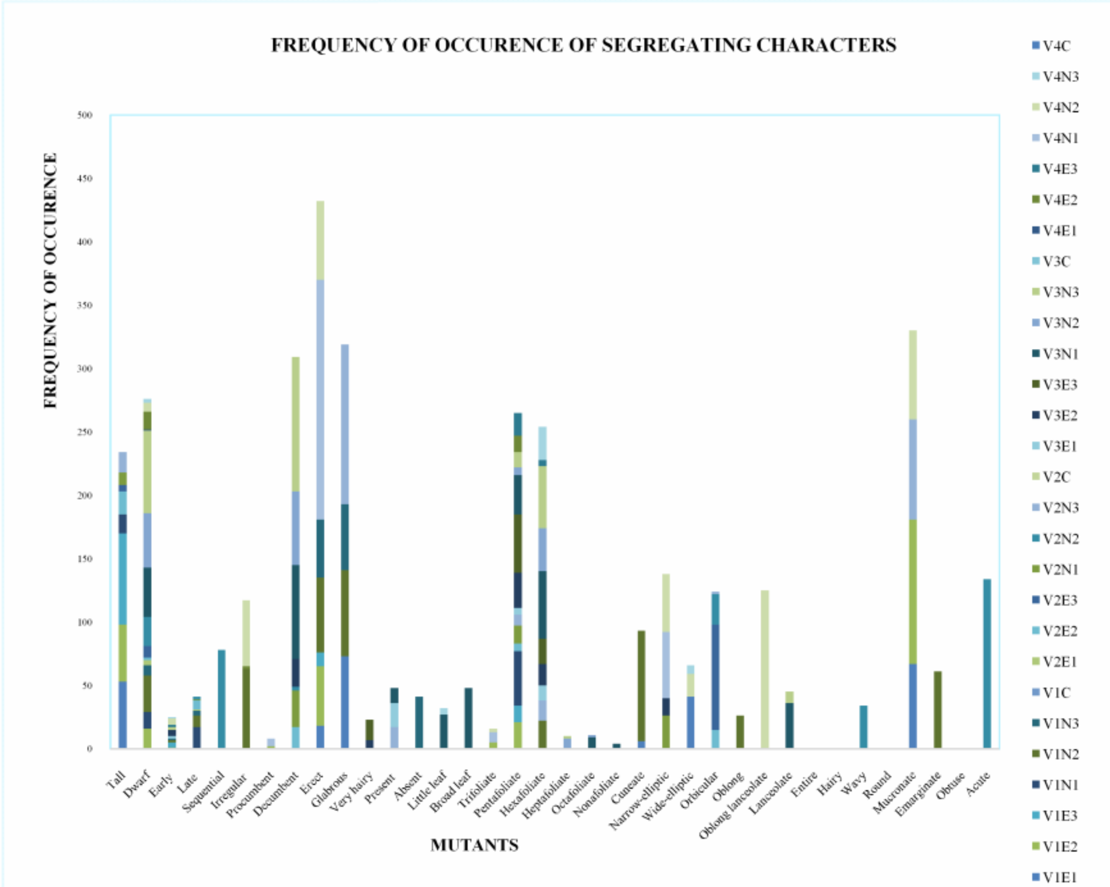


Fig. 2. Frequency of occurrence of segregating characters in the M_2 population.

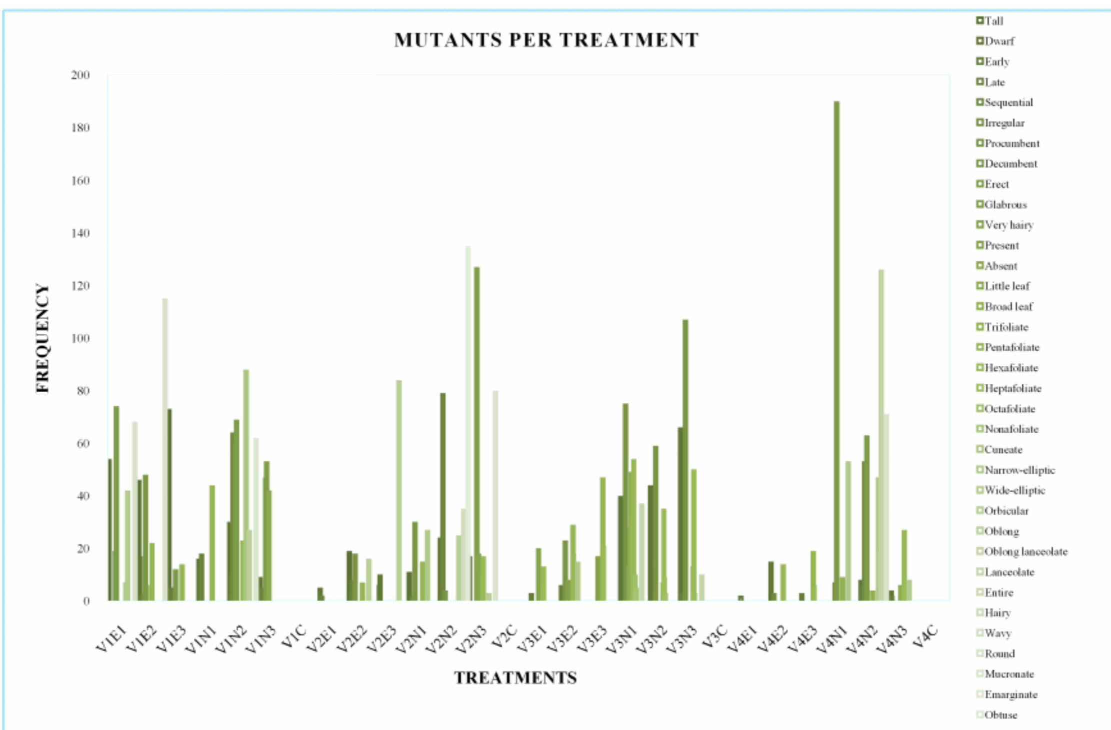


Fig. 3. Frequency of mutants occuring in twenty four treatments in M_2 segregating population.

Table 1: Vegetative trait mutants (aberrations) observed in four groundnut varities in M_2 segregating population in M_2 generation.

Genotypes	Height		Maturity		Branching pattern			Growth habit			Shoot pubescence		Stem pigmentation		Leaflet number								Leaf shape								Leaflet margin				Leaflet Tip				Total	Mutation frequency (%)
	Tall	Dwarf	Early	Late	Alternate	Sequential	Irregular	Procumbent	Decumbent	Erect	Glabrous	Very hairy	Present	Absent	Little leaf	Broad leaf	Trifoliate	Pentafoliate	Hexafoliate	Heptafoliate	Octafoliate	Nonafoliate	Cuneate	Narrow-elliptic	Wide-elliptic	Obovate	Orbicular	Oblong	Oblong lanceolate	Lanceolate	Entire	Hairy	Wavy	Round	Mucronate	Emarginate	Obtuse	Acute		
V_1E_1	53									18	73												6		41										67				258	0.201
V_1E_2	45	16	1					2		47							5	21																	114				251	0.171
V_1E_3	72		4							11								13																					100	0.075
V_1N_1	15	13		17														43																					88	0.058
V_1N_2		29	2	9			63			59	68								22				87					26								61			426	0.289
V_1N_3		8	1	4						46	52			41																									152	0.115
V_1C																																							0	0
V_2E_1		4		1																																			5	0.003
V_2E_2	18	2		7					17									6									15												65	0.045
V_2E_3	5	9																									83												97	0.065
V_2N_1	10			1					29									14						26															80	0.052
V_2N_2		23		2		78			3																		24						34					134	298	0.215
V_2N_3	16										126		17					9	16								2								79				265	0.187
V_2C																																							0	0
V_3E_1			2										19					5	12																				38	0.024
V_3E_2			5						22			7						28	17					14															93	0.070
V_3E_3												16						46	20																				82	0.059
V_3N_1		39							74				12		27	48		31	53		9	4								36									333	0.227
V_3N_2		43							58									6	34	8	2																		151	0.115
V_3N_3		65	2						106									12	49	2										9									245	0.189
V_3C																																							0	0
V_4E_1		1																																					1	0.001
V_4E_2		14					2											13																					29	0.025
V_4E_3			2															18	5																				25	0.023
V_4N_1								6		189							8							52															255	0.190
V_4N_2		7	5				52			62							3							46	18				125						70				388	0.266
V_4N_3		3	1												5				26						7														42	0.037
V_4C																																							0	0
	234	276	25	41	0	78	117	8	309	432	319	23	48	41	32	48	16	265	254	10	11	4	93	138	66	0	124	26	125	45	0	0	34	0	330	61	0	134	3767	2.667

V_1-Smruti, V_2-Devi, V_3-ICGV 7220, V_4-ICGV 2266; E_1-EMS 0.2%, E_2- EMS0.3%, E_3- EMS 0.4% treated; N_1- SA 0.2%, N_2-SA 0.3%, N_3- SA0.4% treated; Boxes in coral represent general features of the variety and Boxes in pink represent unique mutants

CONCLUSIONS

A wide range of mutations (aberrations) were observed in the vegetative traits in M_2 population. A total of 276 dwarf mutants were observed and 823 number of leaf anomaly mutants recorded in the entire population. The mutation frequency of SA treated plants in every variety was higher than the EMS treated population for inducing mutants in vegetative traits. The percentage of mutants occurring was 2.667 which refers to single event of individual mutant considered at a time, but there is a chance of overlapping of two or more mutant traits in a single plant which further decreases the actual number of mutant. V_3 responded very well to SA. plants in the population. This is an important consideration to make while studying the mutant population for individual traits and forwarding the population to next generation. It is to be noted that mutants for vegetative traits help study the effect of different mutagenic doses and developing any uniquemutant into a new variety either directly or in subsequent generations. As vegetative traits are qualitative traits and not affected by environment these do not need stringent methods as pod yield contributing characters. The mutants, mainly dwarf types and early maturing types were forwarded to M_3 generation for yield studies and character stability.

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Conflict of Interest. None.

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