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INDUCED MUTATIONS IN CHICKPEA (*CICER ARIETINUM* L.) IV. TYPES OF MACROMUTATIONS INDUCED

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ABSTRACT

A wide range of chlorophyll and viable morphological mutations affecting almost all the parts of plant and seed characteristic were isolated in M_2 and M_3 generation of chickpea. The spectrum of viable mutations was wider in the relatively mutagen resistant *desi* var. G 130 and green seeded var. L 345 than *desi* var. H 214 and *Kabuli* var. C 104. The wide range of variability for plant type mutations obtained has far exceeded the expectations. Some of these plant type mutants are so uncommon that they are being reported for the first time in this crop. The most striking plant type mutants include Miniature, Dwarfs, Compact, Upright, and Tall. Some of these plant type mutants correspond very closely with the ideotype being looked for in this crop. These mutants can be better fitted in new cropping patterns and with improved agronomic management, their yielding ability may even be better. The spectrum of mutations was dependent upon the nature of the mutagen used. The total types of mutations induced by NMU were higher than with gamma rays and EMS and neutrons, thus indicating that NMU is highly useful mutagen when one is looking for major gene changes. The results also indicated that induced mutability is governed by the genotype of the material used. There is evidence to show that the same mutagen may produce different spectra in different varieties, thus suggesting mutagenic specificity against certain alleles governing characters. A large number of multiple mutations affecting two or more characters were also found.

Key words: Chickpea, viable mutations, macromutations, mutagens

In order to induce variability and utilize useful mutations for efficient plant breeding, the systematic study of induced chlorophyll and viable morphological mutations in M_2 and M_3 generations is the most dependable index. Although studies on spontaneous mutations in chickpea have been undertaken in the past [1-2], limited reports are available on induced viable morphological mutations in chickpea [3-4].

The present investigation was undertaken to understand the response of different *desi* and *kabuli* chickpea genotypes to different types of mutagenic treatment with a view to identify various types of viable morphological mutations (macromutations) in M_2 and M_3 generations in chickpea.

MATERIALS AND METHODS

The material for this study comprised of two *desi* (G 130 and H 214), one *kabuli* (C 104) and one green seeded type (L 345) chickpea genotypes. Five hundred dry seeds with a moisture content of 10-12% approx. were used for each treatment. Three doses each of two physical mutagens, gamma rays (400, 500 and 600 Gy) and fast neutron (5, 10 and 15 Gy) were given. Two concentrations and two durations of the two radiomimetic monofunctional alkylating agents viz., N-nitroso-N-methyle urea (NMU) 0.01% (20h) and 0.02% (8h) and ethylmethane sulphonate (EMS) 0.1% (20h) and 0.2% (8h) at 5.2 pH were used [4]. Dry seeds were used as controls. Treated and control seeds were sown at a spacing of 15 cm in rows of 5 m long and 0.45 m apart on the same day in well prepared seed beds in the field. Each M_1 plant was harvested individually and M_2 progeny raised in separate row following a compact family block CRD layout. The treated as well as control poulations after germination were carefully screened for macromutations throughout the life period of the M_2 and M_3 generation plants in the the field.

RESULTS AND DISCUSSION

The mutations affecting gross morphological changes in branching, stem structure, growth habit, leaf, flower, pod and seed size and maturity etc. were scored as viable macromutations. These were classified according to system suggested by Swaminathan [5]. There were differences in the mutation spectrum both between varieties and mutagenic treatments. However, many similarieties were also noticed between the *desi* and *kabuli* varieties in respect of the spectrum and frequency of a particular mutation. The frequencies of viable macromutations were computed as in the case of chlorophyll mutations [3]. The macromutations induced in the present study are described below.

I. Mutation affecting chlorophyll apparatus :

1) *Chlorina* : Plant colour was very light green or pale green which persisted throughout the growth period. They had normal flowering and fruiting, but had arrested growth. Origin: Var. L 345; Mutagens: Gamma rays, neutrons and NMU.

2) *Chimeral* : Only a branch or half of the plant was either chloretic or reddish brown. Origin: var. G 130; Mutagens: NMU and Gamma rays.

3) *Albinoid* : One completely albinoid branch in a single plant flowered with small white flowers which did not set seed. Origin: Var. L 345; Mutagens: NMU.

II. Mutations affecting leaf morphology :

1) *Supergigas leaf* : A rare true breeding mutant had extremely large, thick, dark

green leaflets with very prominent mid rib (Fig. 1-A-1), thick and semi-erect stem and sparse branching. Large whitish pink flowers had 90% pollen fertility. Origin: Var. L 345; Mutagen : NMU (0.02% 8h)

2) *Gigas leaf* : These mutants were vigourous, upright tall with large thick hairy close pinnae (Fig. 1-A-2). Thick profuse branching at the base. Pods were hairy and large, containing few very bold, hard and wrinkled seeds. Origin: All varieties; Mutagens: neutrons, NMU and EMS.

3) *Broad leaf* : The leaflets were almost similar to those of gigas mutants but the plant as a whole was dwarf with shy branching. The leaves were thick and succulent with broad lamina (Fig. 1-A-3). Pollen sterility was high (45%). Origin: Var. G 130, H 214; Mutagens: all.

4) *Narrow leaf* : The mutant had narrow needle or arrow like long leaflets, tapering towards the tip (Figs. 1-A-4). The pods were longer than control. Apical part of the branches was twining. Origin: All varieties and all mutagens.

5) *Small leaf* : Associated with dwarfness, these mutants had very small leaflets (Fig. 1-A-5). Having light green coloured plants which branched very profusely at the base they bred true. Origin: All varieties and mutagens.

6) *Tiny leaf* : The frequency of this mutation was highest among all the leaf mutants. The mutant had minute needle-like leaflets in the sessile leaf (Figs. 1-A-6). Plants were dwarf, attaining a maximum height of 12-15 cm and had light yellowish-green colour. Origin: all varieties and mutagens.

7) *Stalked leaflet* : This muatnt had a long stalked petiole in each pinnae giving a racket like appearance to the leaflets (Fig. 1-B-1). The pinnae were smaller and light green. Leaflets, rachillas and branches were hairy. Plants were erect, 30-35 cm. tall. Origin: Var. L 345; Mutagens: Gamma rays (400 Gy).

8) *Lobbed pinnae* : This mutant had large pinnae which were bilobbed, trilobbed or even multilobbed. The incision went deep into the lamina, sometimes reaching the mid rib (Fig. 1-B-2). Plants were open, upright, 30-35 cm. tall with profuse branching at the base. Origin: Var. L 345; Mutagens: Gamma rays (400 Gy).

9) *Close pinnae* : A unique mutant having very close leaflets on the rachis (Fig. 1-B-3). The plants were dwarf with thick stem and had pollen fertility upto 70%. The pods were longer and narrower with mostly 3 prominantly beaked seeds in each pod. Origin: All varieties and all mutagens.

10) *Alternifolia mutant* : This mutant had a weak, slender and tall stem with very little branching. The rachis showed a distinctly alternate arrangement of pinnae

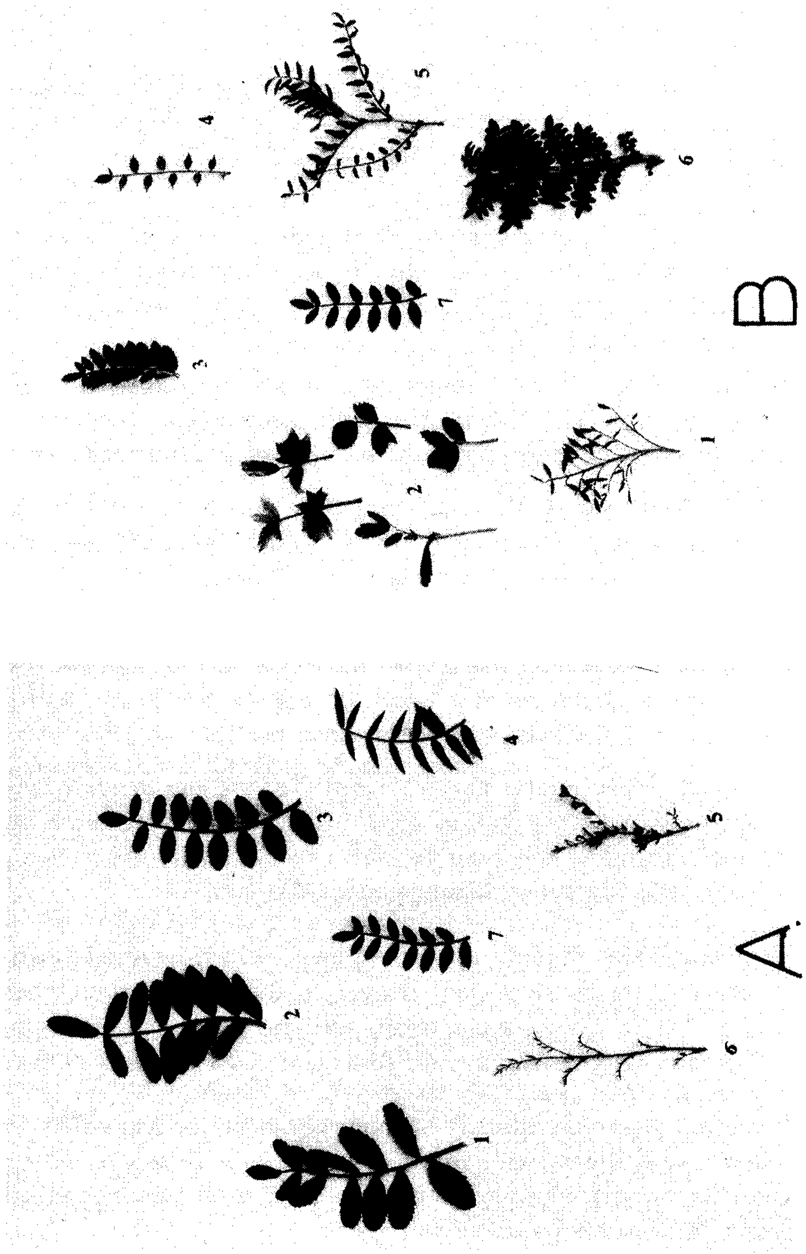

Fig. 1. Leaf morphology mutations : A-1. Supergigas leaf, A-2. Gigas leaf, A-3. Broad leaf, A-4. Narrow leaf, A-5. Small leaf, A-6. Tiny leaf and A-7. Control leaf; B-1. Stalked leaf, B-2. Lobbed leaf, B-3. Close pinnae leaf, B-4. Alternifolia leaf, B-5. Curly leaf, B-6. Fasciata leaf and B-7. Control leaf

which were few, conspicuously serrated and narrow at the tip (Fig. 2-B-4). There were few open bell shaped flowers with reduced keel and wing and a few small pods which had small black seeds. Origin: Var. L 345; Mutagen : NMU (0.02% 8h).

11) *Curly leaf mutant* : This mutant had typical curly leaflets with elongated petiole (Fig. 2-B-5). The plants were erect in habit with pale-green foliage. Origin: Var. H 214; Mutagen : Gamma rays 500 Gy.

12) *Fasciata leaf* : This mutant had thick, succulent and fasciated stem and branches, thick, curled and small closed leaflets (Fig. 2-B-6). The plants were extremely dwarf (10-12 cm.) with brittle branches. Pods were pointed and compactly placed and contained creamwhite seeds. Origin: Var. C 104; Mutagen: NMU (0.01% 20h).

13) *Simple leaf* : This mutant had thick simple leaves with a prominent mid rib and serration (Fig. 2-A). The plants were dwarf (15 cm.) having thick stem and few branches. The mutant bore flowers with orange coloured rudimentary petals and underdeveloped stigma and stamens. Cleistogamous flowers withered without fruiting. Origin: Var.G 130 and H 214; Mutagens: NMU and EMS.

14) *Long leaf* : The mutants were dwarf having narrow and very long leaflets. The distal portions of the branches were dropping because of weak and slender structure. Origin: Var. G 130, H 214 and L 345; Mutagens: NMU and EMS.

III. Mutations affecting growth habit (Plant Type Mutations) :

1) *Upright muatnt* : This dominant mutant was isolated in M_1 generation. It has upright growth habit, branching right at the base, producing 6-12 thick and strong branches (Fig. 2-B). Large but few round hairy, light green leaves and sparse canopy permitting maximum light penetration. The seeds were black roundish, smooth and bold (26.0 g/100 grain weight). Origin: Var. C 104; Mutagen: NMU (0.01% 20 h).

2) *Tall mutant* : The mutants were vigourous and 70 to 90 cm. tall with very few thin branches (Fig. 2-C). Leaflets were larger and thicker. Origin: All varieties; Mutagens: Gamma-rays, NMU and EMS.

3) *Gigas mutant* : These mutants were vigourous, upright tall with large thick, hairy close pinnae (Fig. 2-D). Thick profuse branching at the base. Pods were hairy and large, containing few very bold, hard and wrinkled seeds. Origin: All varieties; Mutagens: Neutrons, NMU and EMS.

4) *Bouquet mutant* : These mutant had profuse branching at the base but the branches remained very close to each other forming a bundle and the canopy of secondary branches and leaves gave an appearance of a beautiful "Bouquet". Origin: Var. G 130 and C 104; Mutagens: NMU and EMS.

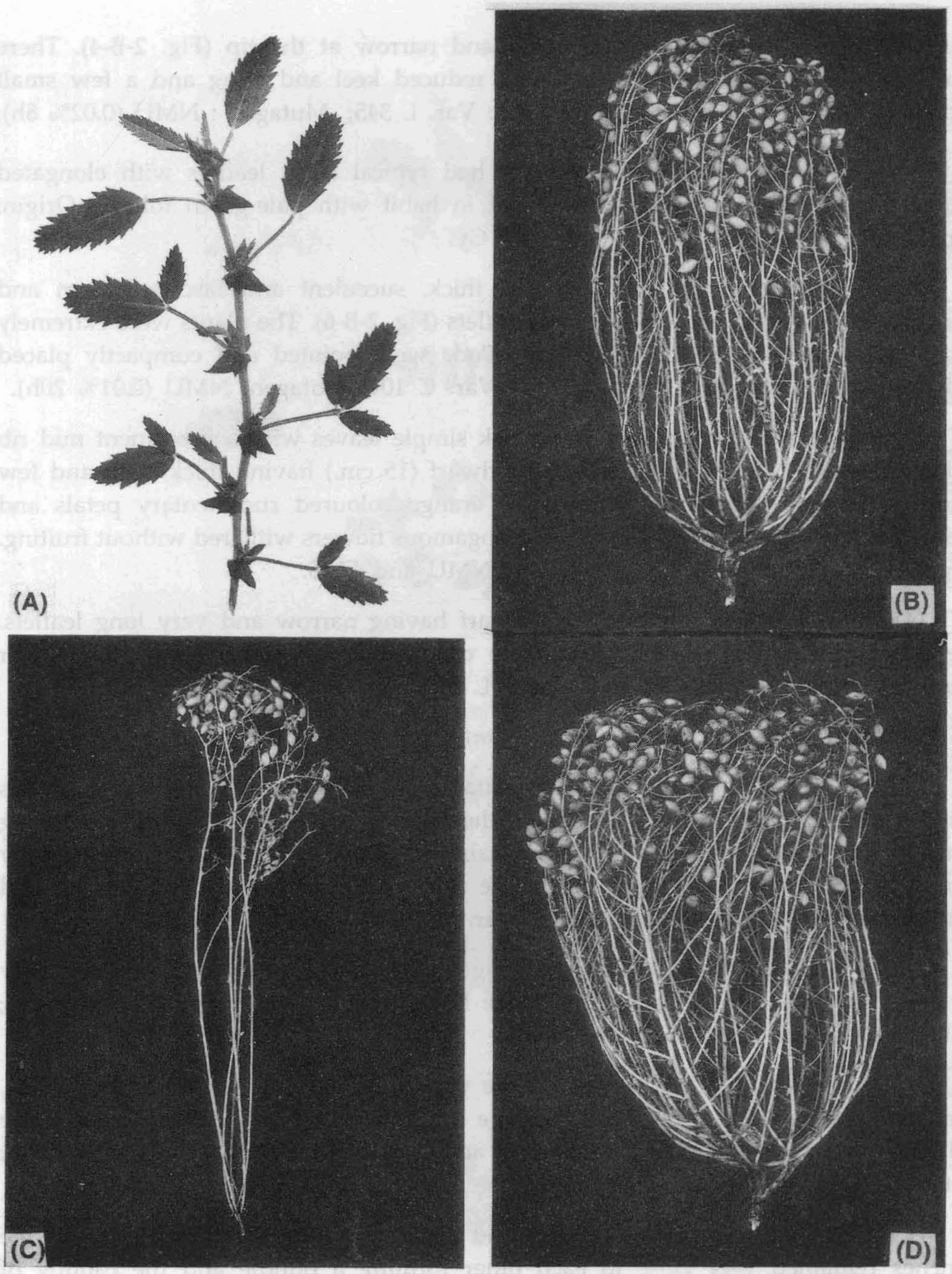

Fig. 2. A. Leaf morphology mutation: Simple leaf mutant;
Fig. 2.B-D. Plant type mutations: B. Upright mutant, C. Tall mutant, D. Gigas mutant

5) *Dwarf mutations* : Depending on reduction of height and appearance, dwarf mutants have been classified into three groups - Miniature, Dwarf and Dwarf bushy.

a) *Miniature* : Plant height in these mutants was extremely reduced and was less than 15 cm (Fig. 3-A). These mutants looked like miniature plants. They had normal leaves, flowering, pollen fertility, fruiting and seed setting. Origin: All varieties and all mutagens.

b) *Dwarf* : The height of these mutants ranged from 15 to 20 cm and had profuse branching at the base which formed a dense umbrella like canopy (Fig. 3-B). Origin: All varieties and all mutagens.

c) *Dwarf bushy* : The height of these mutants ranged from 15 to 20 cm. with profuse branching at the base. The branches were thin with several rachillae towards the top giving bushy appearance (Fig. 3-C). Origin: Var. G 130, H 214 and L 345; Mutagens: NMU and EMS.

6) *Compact mutations* : Mutants showing varying degree of compactness were classified in two groups: a) Compact-1 and b) Compact-2.

a) *Compact-1* : These mutants were dwarf due to reduction in height, condensed internodes and compactness of branches. The branching was profuse at the base giving rise to dense interwoven secondary branches which ultimately made the mutants compact. Origin: All varieties; Mutagens: r-rays and NMU.

b) *Compact-2* : These mutants were similar to Compact-1 in all respects except their large size and vigorous growth. Origin: Var. G 130, L 345 and C 104; Mutagens: Neutrons and EMS.

7) *Fasciated* : This mutant had thick, succulent and fasciated stem and branches, thick, curled and small closed leaflets (Fig. 1-B-6). The plants were extremely dwarf (10-12 cm) with brittle branches. Pods were pointed and compactly placed. Origin: Var. C 104; Mutagen: NMU (0.01% 20h).

8) *Spreading* : These mutants were completely creeping on the ground. The diameter of their spread was about 120 cm (Fig. 3-D) as the branches were 50-60 cm. long, running on the ground. Seeds were shrivelled with hard and rough seed coat. Origin: All varieties and all mutagens.

9) *Twining* : Mutants were very weak, slender, unbranched with very few leaflets. The distal portion of the stem was tendrilled and had twining tendency. Origin: G 130, H 214; Mutagens: Gamma rays, neutrons and NMU.

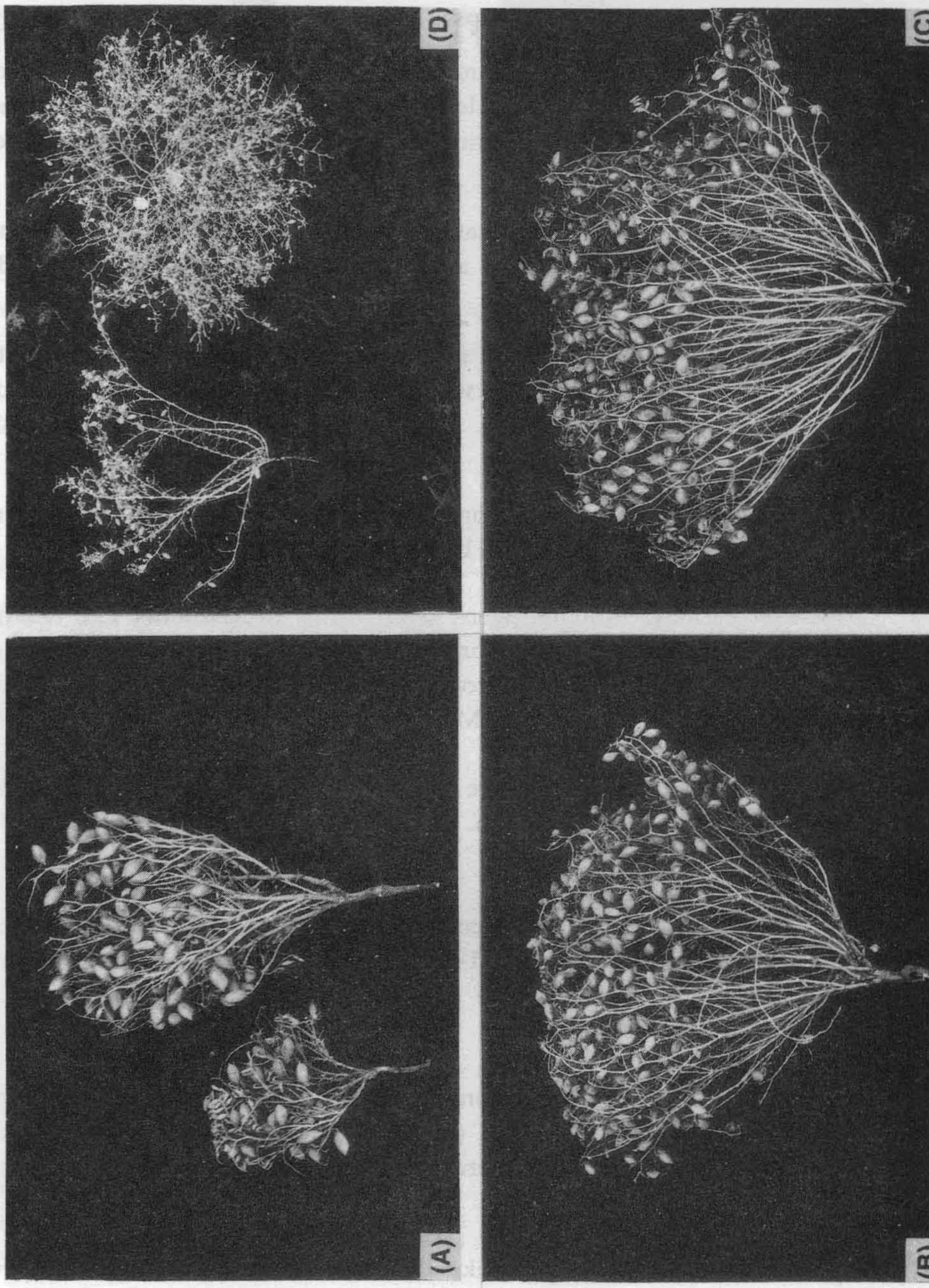

Fig. 3. Plant type mutations: A. Miniature mutants, B. Dwarf mutant, C. Dwarf bushy mutant and D. Spreading mutant with control (left)

10) *Supergigas mutant* : A rare true breeding mutant isolated in M_3 generation had extremely large, thick, dark green leaflets with very prominent mid rib (Fig. 1-A-1), thick and semi-erect stem and sparse branching. Pods were large and prominently beaked with a deep depression on lateral sides (Fig. 4-B-a). Very bold, green, hard and rough seeds had prominent beak. Origin: Var. L 345; Mutagen: NMU (0.02% 8h).

11) *Solitary stem mutant* : Mutant isolated in M_3 generation had solitary and unbranched stem up to the height of 50 cm. and only thereafter 4-5 branches appeared. Only few rachillae with large pinnae were found. Origin: Var. L 345; Mutagen: NMU (0.02% 8h).

12) *Erect mutant* : The muatnt was erect and tall (60 cm.) with shy branching and light green pinnae. Origin: Var. G 130; Mutagen: NMU (0.02% 8h).

IV. Mutations affecting flower characters :

Flower mutations

1) *Open flower* : This mutant had bell shaped flowers with open keel and wings not adhering to each other to form the papilionacious flower. The pistil and androecium were exposed (Fig. 4-A). Plants were short with few branches and open canopy. Very early in flowering and maturity, the mutants had dark brown, flattened seeds with wrinkles. Origin: Var. H 214; Mutagen: Gamma rays (400 Gy).

2) *Two-tier inflorescence* : A unique mutation not reported so far was isolated in M_3 generation. The flower originating from a normal pedicel was rudimentary with prominent sepals and gave rise to another pedicel and flower from its own thalamus (Fig. 4-B-c). The terminal flower was also rudimentary, closed and sterile. Origin: Var. L 345; Mutagen: NMU (0.02% 8h).

3) *Malformed flower mutant* : The flowers of this mutant isolated in M_3 generation looked very unusual as they were very small having rudimentary and malformed organs. The petals did not stretch fully and were folded without distinction from each other. Pistil and androecium could easily be seen as they were not enclosed by the keel. Due to very high (80%) pollen sterility there was no seed setting. Origin: Var. G 130 Mutagen: NMU (0.02% 8h).

V. Mutations affecting maturity :

1) *Early mutant* : Associated with dwarfness the mutants induced by NMU in var. G 130, flowered and matured 10-20 days earlier than the control.

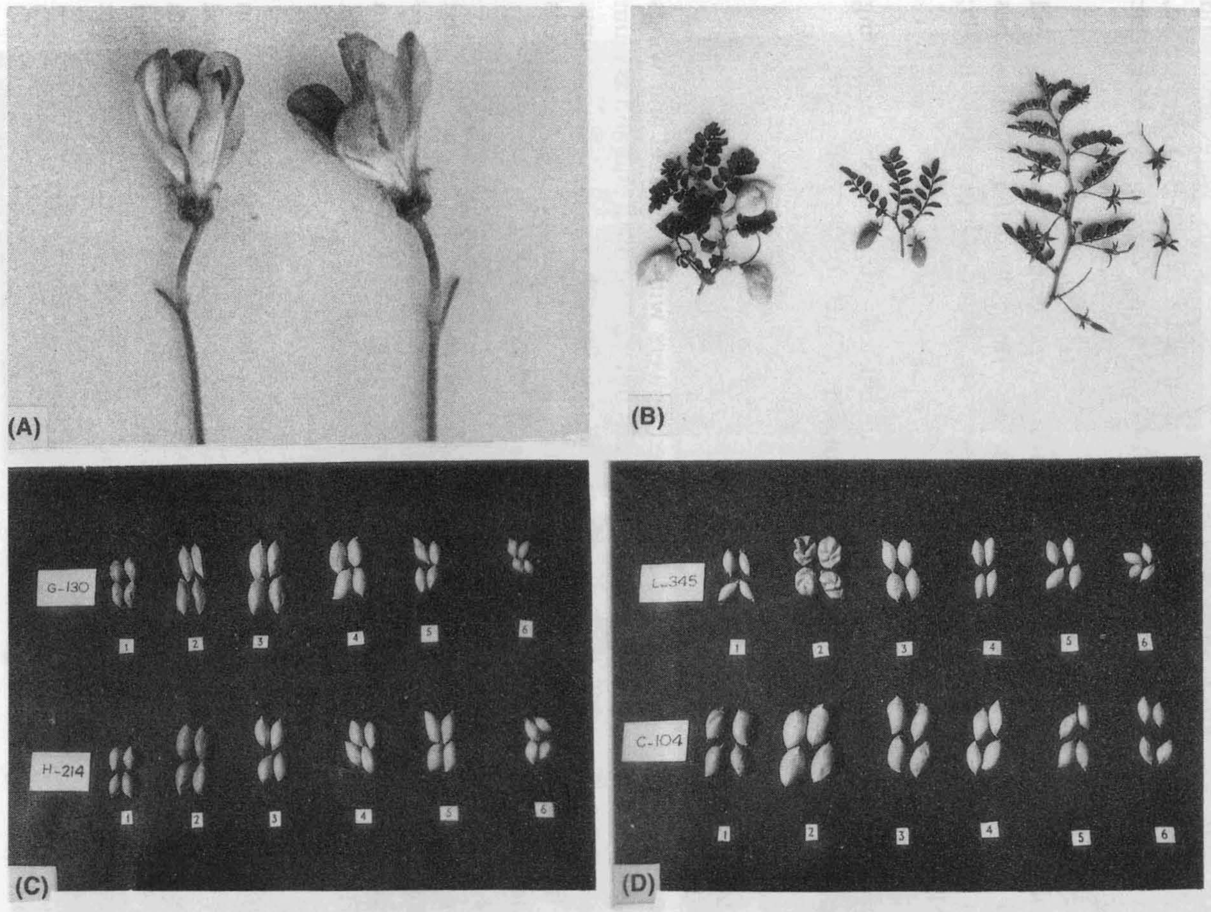

Fig. 4. Flower and pod mutations: Flower mutations: A. Open flower mutant, B. (a) Supergigas mutant twig with pods (left), (b) Control plant twig (centre) and (c) Two-tier inflorescence mutant twig (right); Pod mutations: C. (a) var. G 130, (b) var. H 214; D. (a) var. L 345 and (b) var. C 104: 1. Control pods, 2. Gigas pod, 3. Long pod, 4. Large pod, 5. Narrow and elongated pod and 6. Small pod mutant

2) *Late mutant* : Mutants induced by NMU in var. G 130 with broad and thick dark green colour foliage were always associated with dwarfness and flowered and matured 15-20 days late.

VI. Mutations affecting pod characters :

Pod mutations: (Fig. 4-C&D)

1) *Gigas pod mutant* : Associated with gigas plant type the mutant had very large pods containing 2-3 bold seeds per pod (Fig. 4-C&D-2).

2) *Long pods* : Mutants had comparatively much longer pods containing 3-4 seeds per pod (Fig. 4-C&D-3).

3) *Large pods* : The mutants had comparatively larger pods containing 2-3 bold seeds per pod. (Fig. 4-C&D-4).

4) *Narrow and elongated pods* : The mutants had narrow and elongated pods with 2-3 normal seeds (Fig. 4-C&D-5).

5) *Small pods* : Associated with dwarfness the mutants had very small pods containing 1-2 small seeds per pod (Fig. 4-C&D-6).

6) *Double podded* : The mutant plants bore two pods on a single peduncle. Both the pods contained two seeds in each case.

VII. Mutations affecting seed colour, shape and size :

A large number of seed coat colour, size and shape mutants were isolated in M_2 generation. Many of these mutants were having strong association with several other mutant characteristics such as tallness, dwarfness, foliage modification and plant type etc. In all 39 types of changes for seed colour and 8 for shape and size were isolated and are grouped variety-wise (Fig. 5).

In addition to a large number of simple viable mutations, multiple mutations affecting two or more characters were found common in the present study. Patil [6] attributed this phenomenon to either mutation of pleiotropic gene, or mutation of gene clusters or due to loss of chromosomal segments. Gaul [7] interpreted the occurrence of such mutants as due to chromosomal rearrangements or deletion.

Mutations affecting leaf morphology, growth habit and plant type appeared more frequently in *desi* varieties under chemical mutagens than with radiations. Out of the total number of viable mutations scored, 45% belonged to leaf morphology, 33% to growth habit, 19% to seed colour mutations and rest to all other types of mutations. Of all the mutations induced by different mutagens 42.7% were produced by NMU alone and the rest by gamma rays, neutron and EMS in about equal

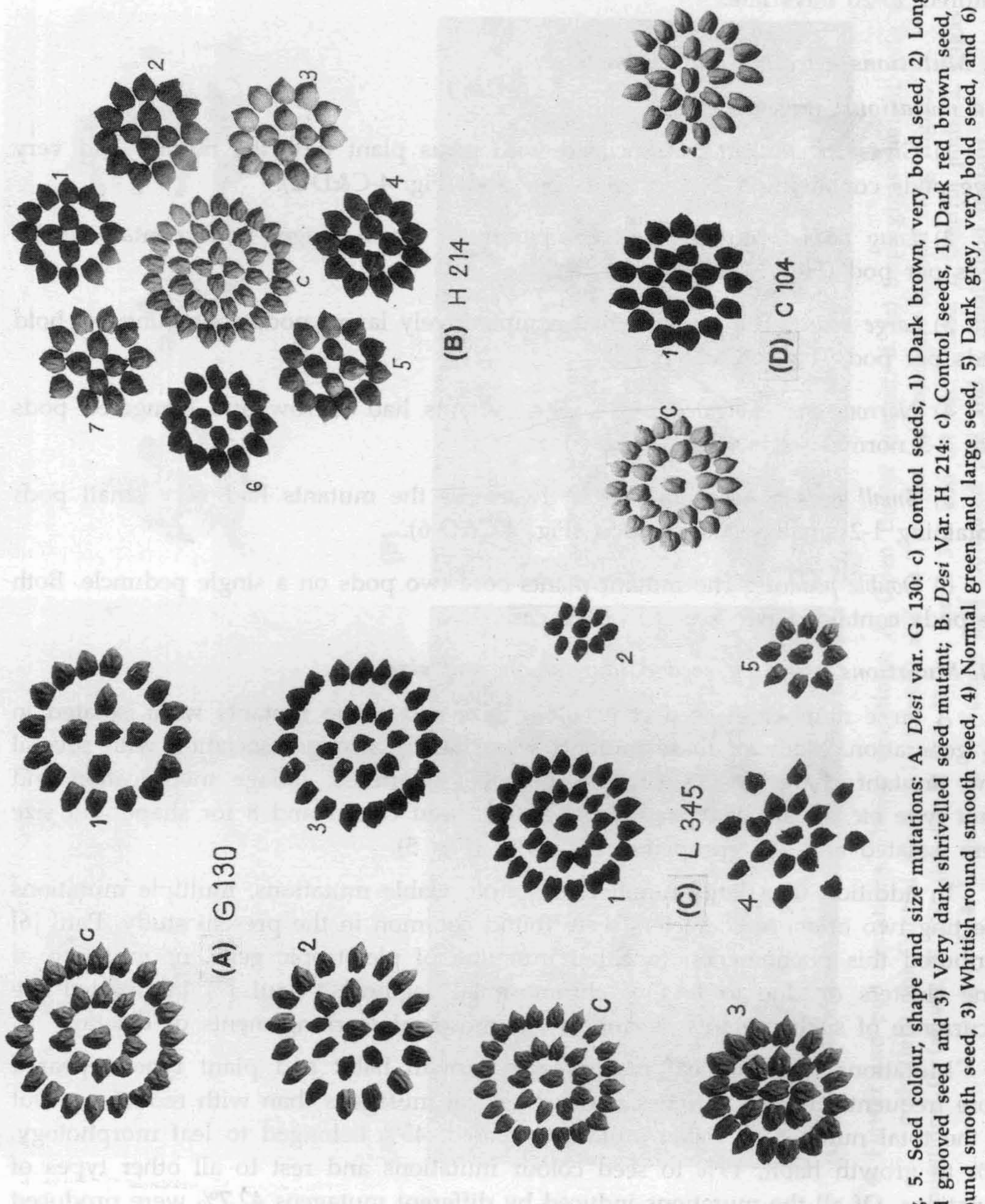

Fig. 5. Seed colour, shape and size mutations: A *Desi* var. G 130: c) Control seeds, 1) Dark brown, very bold seed, 2) Long bold and grooved seed and 3) Very dark shrivelled seed mutant; B *Desi* Var. H 214: c) Control seeds, 1) Dark red brown seed, 2) Red round smooth seed, 3) Whitish round smooth seed, 4) Normal green and large seed, 5) Dark grey, very bold seed, and 6) Dark brown black mutant; C Green seeded var. L 345: c) Control seeds, 1) Shining black seed, 2) Wrinkled small seed, 3) Brownish-green bold seed, 4) Black-dull brown seed, and 5) Dull red-brown bold seed mutant; D. *Kabuli* var. C 104: c) Control seeds, 1) Black, very bold seed, and 2) Long seed mutant

numbers. Frequency of mutations on variety basis indicated almost equal response of the three genotypes, green seeded var. L 345, *desi* var. G 130 and var. H 214, while *kabuli* var. C 104 showed poorest response.

Spectrum of seed coat colour, shape and size mutants

***Desi* var. G 130** (Fig. 5-A-C). (original seed colour: yellowish brown)			
1.	Dark brown, very bold (Fig. 5-A-1)	2.	Long bold and grooved (Fig. 5-A-2)
3.	Greenish yellow shrivelled (Fig. 5-A-3)	4.	Very dark brown blackish
5.	Greyish brown	6.	Yellow brown, bold
7.	Reddish brown	8.	Mosaic
9.	Shrivelled seed		
***Desi* var. H 214** (Fig. 5-B-C). (original seed colour: reddish brown)			
1.	Dark red brown (Fig. 5-B-1)	2.	Red round, smooth (Fig. 5-B-2)
3.	Whitish, round smooth (Fig. 5-B-3)	4.	Normal green, large (Fig. 5-B-4)
5.	Dark grey, very bold (Fig. 5-B-5)	6.	Dark brown black (Fig. 5-B-6)
7.	Greenish, round smooth (Fig. 5-B-7)	8.	Mosaic, dull brown
9.	Dark brown, round smooth	10.	Brownish grey
11.	Reddish brown, round smooth	12.	Dull greenish brown, smooth
13.	Greyishdark brown, shrivelled	14.	Light green white, round smooth
15.	Dull brown hard, bold	16.	Brownish, round smooth
17.	Shrivelled	18.	Bold, large, hard
Green seeded var. L 345 (Fig. 5-C-C). (original seed colour: dark green)			
1.	Shining black (Fig. 5-C-1)	2.	Wrinkled small seeded (Fig. 5-C-2)
3.	Brownish green, bold (Fig. 5-C-3)	4.	Black dull brown, bold (Fig. 5-C-4)
5.	Dull red brown, bold (Fig. 5-C-5)	6.	Reddish brown, green
7.	Dull black	8.	Dense mosaic on brown
9.	Mosaic on green	10	Green, hard rough
11.	Green smooth with mosaic	12.	Light greenish brown
13.	Greyish black green		
***Kabuli* var. C 104** (Fig. 5-D-C). (original seed colour: salmon coloured)			
1.	Black, bold (Fig. 5-D-1)	2.	Long seeded (Fig. 5-D-2)
3.	Dull green, round smooth	4.	Brownish with grooves
5.	Reddish brown, round smooth	6.	Bold seeded
7.	Flattened seeded		

Table 1. Means over controls in thirteen macromutants for seven quantitative characters

Variety & Mutant	No. of plants	Grain yield/ plant ± SE	No. of pods/ plant ± SE	No. of grains/ pod ± SE	100 grain weight (g) ± SE	Biological yield/ (g) ± SE	Harvest index (%) ± SE	Protein content (%)
***Desi* var. G 130**								
Control	100	28.9 ± 0.7	179 ± 4.9	1.27 ± 0.02	12.81 ± 0.08	60 ± 1.5	48.0 ± 0.4	24.5
Mutants								
Close pinnae	15	23.5 ± 1.9	137 ± 12.3	1.73 ± 0.10	10.31 ± 0.23	62 ± 8.7	43.1 ± 2.5	30.2
Gigas	15	50.4 ± 1.9	213 ± 16.9	1.88 ± 0.10	13.41 ± 0.17	98 ± 3.1	51.7 ± 0.8	26.0
***Desi* var. H 214**								
Control	100	25.5 ± 0.7	150 ± 4.9	1.30 ± 0.02	13.34 ± 0.08	55 ± 1.5	46.5 ± 0.4	23.6
Mutants								
Dwarf bushy	15	35.4 ± 3.2	258 ± 16.4	1.19 ± 0.05	11.31 ± 0.28	80 ± 6.2	44.2 ± 1.7	26.7
Red-round & smooth	45	44.3 ± 2.5	280 ± 14.0	1.28 ± 0.06	12.76 ± 0.18	108 ± 5.0	41.5 ± 1.7	23.2
***Kabuli* var. C 104**								
Control	100	26.9 ± 0.7	113 ± 3.2	1.12 ± 0.01	21.36 ± 0.15	61 ± 1.4	43.7 ± 0.4	22.8
Mutants								
Upright mutant	60	54.5 ± 2.4	178 ± 9.3	1.33 ± 0.03	23.84 ± 0.25	124 ± 5.1	44.7 ± 1.3	27.1
Green seeded var. L 345								
Control	100	27.9 ± 0.7	197 ± 4.9	1.19 ± 0.01	11.97 ± 0.07	57 ± 1.2	48.5 ± 0.4	24.6
Mutants								
Gigas-1	105	50.0 ± 1.4	267 ± 9.5	1.08 ± 0.02	17.87 ± 0.18	105 ± 3.0	47.6 ± 0.4	24.9
Gigas-2	30	33.7 ± 2.4	232 ± 16.3	1.48 ± 0.07	10.15 ± 0.28	73 ± 4.9	45.0 ± 1.2	20.3
Supergigas	15	44.4 ± 2.8	193 ± 16.9	1.35 ± 0.07	18.11 ± 0.20	86 ± 5.5	48.5 ± 0.9	23.2
Compact-1	45	46.3 ± 1.8	279 ± 11.4	1.29 ± 0.04	13.16 ± 0.21	98 ± 3.9	47.8 ± 1.1	27.8
Compact-2	15	42.2 ± 1.9	239 ± 14.8	1.60 ± 0.08	11.42 ± 0.38	87 ± 4.9	49.6 ± 1.4	24.7
Tall	15	39.1 ± 2.4	231 ± 17.5	1.47 ± 0.10	11.86 ± 0.21	91 ± 5.3	44.6 ± 2.8	28.0
Dwarf	30	31.4 ± 1.5	292 ± 10.0	1.07 ± 0.04	10.06 ± 0.10	86 ± 2.8	36.5 ± 1.0	27.1
Spreading	15	34.8 ± 4.3	206 ± 30.9	1.39 ± 0.07	12.92 ± 0.27	87 ± 9.4	40.0 ± 2.3	22.7
GM (Controls)	400	27.3	160	1.22	12.7	58	46.7	23.9
GM (Mutants)	420	40.8	231	1.39	12.8	91	45.0	25.5

Isolation of potentially useful mutations - Plant Type Mutations :

A systematic and continuous search during the growth period was made for morphological mutations in general and plant type mutations in particular induced by mutational changes of the 'major' genes resulting into 'macromutations' in the segregating M_2 population. The evolutionery history of chickpea indicates that the present varieties have been evolved in response to stress conditions and consequently they show a plant type which lacks many of the characteristics expected in high yielding varieties[8]. For example, they tend to be bushy, spreding and indeterminate and also take too much time to mature. It should obviously be useful to develop erect plant type with a large number of primary and secondary branches which do not cover too much ground and also mature in a shorter time period. In this way response to increase plant population per unit area becomes possible and also to tailor the canopy so that a greater amount of light penetrates through lower branches.

The present studies in respect of isolation of 'macromutations' and particularly plant type mutations have been remarkably successful. The most striking plant type mutants include Miniature, Dwarfs, Compact, Upright and Tall. Some of these mutants correspond very closely with the kind of ideotype one would like to see in chickpea crop[9]. Some of these macromutants have been tested for their yielding ability also and have been found to be superior to their parent varieties in several respects as is evident from the results presented in Table 1.

Evaluation of macromutants in M_3 generation :

Table 1 summarise the data on various quantitative characters studied in 13 macromutants (two each in *desi* varieties G 130 and H 214, one in *Kabuli* var. C 104 and eight in green seeded var. L 345) in M_3 generation. Normally one does not expect a raw mutant even for an improved plant type to give strikingly high yield compared to the parent varieties. Even so several of the plant type mutants isolated in the present study have appeared highly promising. The ones which have given high yield than parent varieties (Table 1) include Gigas, Dwarf, Compact and Upright mutant. There is reason to believe that with improved agronomic management their yielding ability may be even better. Some of the useful characters associated with these plant type mutants are erect and upright growth habit, more number of primary and secondary branches, open sparse canopy for better light penetration, large number of pods and seeds per plant, more than two seeds per pod, large seed size, high grain yield and high harvest index. In addition, the different plant type mutants have provided useful genetic stock of a kind, which are not readily available in chickpea crop. For example, the Upright mutant of *Kabuli* var. C 104 with black and bold seeds has been found to be highly resistant to *Ascochyta* blight as well as *Fusarium* wilt disease of chickpea.

The enormous variability which the different mutagenic treatments have generated in terms of plant type mutations raises some fundamental questions. Is chickpea unique in this respect ? This would appear to be most unlikely. The probable explanation for unprecedented release of genetic variability in this study could be that the natural selection for survival has been so drastic in chickpea that only one kind of primitive plant architecture with poor harvest index has survived [8]. The mutagenic treatments may have merely helped to regenerate the variability lost in the process of natural selection for adaptation to stress conditions. If this explanation is accepted, a new role will emerge for induced mutations. Mutation breeding on this basis can be expected to be particularly rewarding in subsistance farming crops like legumes in general and chickpea in particular. The role of induced mutations in crop improvement is evident from a large number of improved high yielding varieties of several crops developed through mutation breeding and released for commercial cultivation in India [10].

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