Figure Plates
Figure Plate 1 - Seedling Abnormalities in *V. faba* induced by gamma rays and gamma rays + Chemical Mutagens (*M₁* generation):

**Fig A**: Control: Normal Cotyledonary and Vegetative leaves

**Fig B**: Erect seedling with deeply notched vegetative leaves forming lobes (20 KR gamma rays)

**Fig C**: Erect seedling with small, round & acute vegetative leaflets (30KR gamma rays)

**Fig D**: Cotyledonary leaves, well developed, notching at the apex in vegetative leaflets, round apex (30KR gamma rays).

**Fig E**: Poorly developed cotyledonary and vegetative leaves with serrate margin and deshaped, stunted growth (40KR gamma rays).

**Fig F**: Cotyledonary leaves forming cup shaped structure, vegetative leaves notched (5KR γ rays + 2.00% SA).

**Fig G**: Poorly developed cotyledonary leaves, unequal leaflets in vegetative leaves, lamina of leaflets forming cup shape structure (10KR γ rays + 1.00% SA).

**Fig H**: Rudimentary cotyledonary leaves, one vegetative leaflet well developed, while others rudimentary (20KR γ rays + 2.00% SA).

**Fig I**: Cotyledonary leaves rudimentary. vegetative leaflets unequal with wavy margin (30KR gamma rays + 2.00% SA)

**Fig J**: Apical vegetative leaves condensed due to condensation in nodes and internodes with deeply notched to form four lobes. Older leaves normal with round apex (10KR γ rays + 2.00% caffeine).

**Fig K**: Poorly developed cotyledonary and vegetative leaves forming undifferentiated aggregate structure (30 KR γ rays + 0.25% caffeine).

**Fig L**: Small thick cotyledonary leaves, vegetative leaflets forming cup shaped structure (40KR γ rays + 2.00% caffeine).
FIGURE PLATE 1 - Seedling abnormalities in *V. faba* induced by gamma rays and gamma rays + chemical mutagens (M*1* Generation).
Figure Plate 2 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays and gamma rays + caffeine (*M*₅ generation):

Fig A: Normal seedlings with normal paripinnately compound leaves bearing obovate, round and smooth leaflets (control).

Fig B: (1) Erect seedlings with two types of leaves - upper normal obovate and lower ones smaller round, some leaflets rudimentary.

(2) One seedling showing delayed germination and rudimentary (10KR gamma rays).

Fig C: Erect dwarf seedling with no branching, growth and leaf formation very poor (30KR gamma rays).

Fig D: Erect seedlings with increased number of branches and leaves (30KR γ rays + 1.00% caffeine).

Fig E: Semi erect seedling with less number of branches, leaves obovate with round and acute apices, one branch highly developed with bigger leaves and round apex showing chimeral effect (30KR γ rays + 2.00% caffeine).

Fig F: Semi erect plant with smaller obovate leaves (40KR γ rays + 0.25% caffeine).

Fig G: Erect seedling with increased number of branches and leaves, bushy, hard and thick stem, 6 leaflet in each rachis (40KR γ rays + 1.00% caffeine).

Fig H: Erect seedling with less number of branches, one side branch has smaller leaves while other bears rudimentary leaves (40KR γ rays + 1.00% caffeine).
FIGURE PLATE 2 - Morphological abnormalities in older seedlings of *V. faba* induced by gamma rays and gamma rays + caffeine (M$_1$ Generation).
Figure Plate 3 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays + caffeine (*M₁* generation):

**Fig A**: Normal seedlings (control)

**Fig B**: Generally seedlings smaller than control (1) Xantha type mutant (2) Albino mutant (5KR 𝜈 rays + 2.00% caffeine).

**Fig B'**: Same as above (enlarged), one smaller seedling is albino, while others Xantha type mutants.

**Fig C**: Chlorophyll mutant longer as compared to other treated seedlings with under developed leaves. Cotyledonary and few vegetative leaves completely albino, while younger vegetative leaves developing chlorophyll so as to form Xantha type, other treated seedlings showing thicker obovate leaves with prominent midrib and slow growth (10KR 𝜈 rays + 1.00% caffeine).
FIGURE PLATE 3 - Morphological abnormalities in older seedlings of *V. faba* induced by gamma rays + caffeine (M₁ Generation)
Figure Plate 4 - Leaf Variations induced by different mutagens in \textit{V. faba} (M\textsubscript{1} generation):

**Fig A:** Leaf variations induced by gamma rays:
1. Control; 2. Small \& round (10KR); 3 \& 4 - unequal (20KR); 5-three lobed (30KR); 6-thick mid rib and slightly notched (40KR).

**Fig B:** Leaf variations induced by gamma rays + SA:
2-4, 6, 10, 11-Deshaping (5KR + 1.00\%, 10KR + 0.25\%, 20KR + 1.00\%, 30KR + 1.00\% respectively); 5, 8, 12-unequal lobed (5KR + 2.00\%, 10KR + 2.00\% and 30KR + 2.00\% respectively); 7-three lobed (10KR + 1.00\%); 9 and 13 - notching (20KR + 0.25\% and 40KR + 0.25\% respectively).

**Fig C:** Leaf variations induced by gamma rays + caffeine:
1. Control, 2 and 3 - small and round (5KR + 0.25\% and 5KR + 1.00\%), 4, 6, 9, 13-unequal lobed (10KR + 0.25\%, 10KR + 2.00\%, 20KR + 2.00\% and 40KR + 2.00\% respectively), 5-fused leaflets (10KR + 1.00\%), 7, 8, 10, 12-notched (10KR + 2.00\%, 20KR + 0.25\%, 30KR + 1.00\% and 40KR + 1.00\% respectively), 11-thick mid rib (40KR + 0.25\%).

**Fig D:** Leaf variation induced by SA
1. Control; 2. slightly notched (0.50\%); 3, 13 and 14-deeply notched (0.50, 1.50 and 1.50\% respectively); 4, 7 \& 8-thick mid rib (0.50\%, 0.75\% \& 1.00\% respectively); 5-unequal (0.75\%); 6 and 10-deshaped (0.75 and 1.00\%); 9, 11 \& 15 round shape (1.00, 1.25\% and 1.50\% respectively) and 12-linear (1.25\%).

**Fig E:** Leaf variations induced by aniline:
1. Control; 2, 3, 6 and 12-deshaped (0.50, 0.50, 0.75 and 1.50\% respectively); 4, 5, 8, and 17 - round shape (0.50, 0.75, 1.00 and 2.00\% respectively); 7, 9, 13 and 14 unequal lobed (0.75, 1.00, 1.50 and 1.75\% respectively); 10-three lobed (1.25\%); 11-fused and deeply notched (1.25\%); 15-normal (1.75) and 16-slightly notched (2.00\%).
FIGURE PLATE 4 - Leaf variations induced by gamma rays, gamma rays + SA, gamma rays + caffeine, SA and aniline in *V. faba* (M₁ Generation).
Figure Plate 5 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays (*M₂* generation):

Fig A: Seedlings with obovate, entire, obtuse and smooth leaflets (control).

Fig B: Albino type mutant with wavy leaf margin. Some older leaves Xantha type, slower growth rate as compared to control (20KR gamma rays).

Fig C: Erect seedlings with two type of leaves: older leaves are broader, obovate with obtuse apex while younger leaves smaller, ovate with acute apex (20KR gamma rays).
FIGURE PLATE 5 - Morphological abnormalities in older seedlings of *V.faba* induced by gamma rays (M2 Generation).
- Figure Plate 6 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays + SA (*M₂* generation):

Fig A : Dwarf sterile seedlings with small round, thick, rudimentary leaves, one pair of leaflets bigger and normal (5KR γ rays + 0.25% SA)

Fig B : Dwarf plants, showing delayed germination and Xantha type mutants. Some leaves underdeveloped (5KR γ rays + 1.00% SA).

Fig C : Erect seedlings bearing younger lanceolate leaves with acute apices, while broader lower leaves with obtuse apices (5KR γ rays + 2.00% SA).
FIGURE PLATE 6 - Morphological abnormalities in older seedlings of *V. faba* induced by gamma rays + SA (M2 Generation).
Figure Plate 7 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays + SA (M2 generation):

**Fig A:** Dwarf seedlings with broad leaves, one seedling shows fusion of vegetative leaflets while other deeply notched, due to incomplete division of leaflets (10KR γ-rays + 0.25% SA).

**Fig B:** Erect seedlings with deeply notched leaflets (20KR γ-rays + 0.25% SA).

**Fig C:** Erect seedling with increased number of branches arising from ground level. Main branch bearing broader leaves as compared to side branches (30KR γ-rays + 0.25% SA).
FIGURE PLATE 7 - Morphological abnormalities in older seedlings of *V. faba* induced by gamma rays + SA (M₂ Generation).
Figure Plate 8 - Morphological Abnormalities in older seedlings of *V. faba* induced by gamma rays + caffeine (*M_2* generation):

**Fig A:** Tall plant with increased number of branches and leaves. Some leaflets show rough, thick and leathery surfaces with undulate margin, while others are lanceolate type. (10KR γ rays + 2.00% caffeine).

**Fig B:** Erect seedlings with notched leaflets and reduced number (20KR γ rays + 1.00% caffeine).

**Fig C:** Erect seedling - one rachis has rudimentary and deshaped leaflets and other with three leaflets arising from single apex. Lower leaves thicker and deshaped (30KR γ rays + 0.25% caffeine).

**Fig D:** Erect seedling, side branches bearing thick broader condensed leaflets due to reduced internodes (30KR γ rays + 2.00% caffeine).
FIGURE PLATE 8 - Morphological abnormalities in older seedlings of *V. faba* induced by gamma rays + caffeine (M$_2$ Generation).
Figure Plate 9 - Morphological Abnormalities in *V. faba*
induced by gamma rays + caffeine and SA (*M₂* generation):

Fig A : Seedlings of Varied heights.
One dwarf seedling with increased number of branches and smaller
and notched leaflets (30KR γ rays + 1.00% caffeine).

Fig B : Small seedlings with thick obovate and round leaflets, obtuse apex
and prominent midrib (40KR γ rays + 1.00% caffeine).

Fig C : Xantha type mutant with variegated leaflets (0.50% SA).

Fig D : Erect seedling with thick deeply notched and deshaped leaflets
(0.75% SA).
FIGURE PLATE 9 - Morphological abnormalities in V. faba induced by gamma rays + caffeine and SA (M+ Generation).
Figure Plate 10 - Morphological Abnormalities in older seedlings of *V. faba* induced by SA (M$_2$ generation):

Fig A: Small seedlings with lanceolate leaflets and acute apices (1.00% SA).

Fig B: Erect seedling with thicker leaflets, incomplete fusion of two older leaflets resulting in notching (1.25% SA).

Fig C: Small seedling with thick, bigger, round leaflets and apically condensed (1.50% SA).
FIGURE PLATE 10 - Morphological abnormalities in older seedlings of *V. faba* induced by SA (M2 Generation).
Figure Plate 11 - Morphological Abnormalities in older seedlings of \textit{V. faba} induced by aniline (M$_2$ generation):

Fig A : Erect seedlings with notching in older leaflets (a), fusion of two leaflets forming unequal lobes (b) (1.00\% Aniline).

Fig B : Erect seedlings with broader, obtuse leaflets in majority (1.25\% Aniline).

Fig C : Erect seedling with deshaped leaflets due to fusion, other leaves obovate but longer than control (1.75\% Aniline).

Fig C' : Fig C - enlarged.
FIGURE PLATE 11 - Morphological abnormalities in older seedlings of *V.faba* induced by Aniline (*M₂* Generation).
**Figure Plate 12 - Morphological Abnormalities in Older Seedlings of V. faba induced by aniline, SA and Gamma rays + caffeine (M_2 generation):**

**Fig A:** Erect seedling with small round leaflets (1.75% Aniline).

**Fig B:** Erect seedling with rudimentary, deshaped and bifurcated leaflets. Younger leaflets varying in shape and size (2.00% Aniline).

**Fig C:** Three seedlings showing xantha type chlorophyll mutant with underdeveloped curly leaflets (1.25% SA).

**Fig C':** Fig C - enlarged.

**Fig D:** Seedling with unequal leaflets, smaller leaflets with rough surface (20KR γ rays + 0.25% caffeine).

**Fig E:** Deep furrows forming two and three lobes in the leaflets. Affected leaflets showing rough surface (40KR γ rays + 0.25% caffeine).
FIGURE PLATE 12 - Morphological abnormalities in *V. faba* induced by Aniline, SA and Gamma rays + caffeine (M₂ Generation).
Figure Plate 13 - Selected Mutants of *V. faba* in M₃ Generation:

**Fig A**: Erect bushy mutant with woody stem bearing green broader leaflets with generally obtuse apex (5KR γ rays + 2.00% SA).

**Fig B**: Tall mutant with less number of branches. Leaflets are narrower and lanceolate (20KR γ rays + 0.25% SA).

**Fig C**: Tall bushy mutant with more number of branches, leaflets and high yield (30KR γ rays + 0.25% SA).

**Fig D**: Dwarf, erect mutant with lesser number of leaflets and decreased yield (10KR γ rays + 0.25% caffeine).

**Fig E**: Tall, bushy mutant with weak stem but contains more number of branches (12 branches) (10KR γ rays + 2.00% caffeine).

**Fig F**: Tall mutants with narrow elongated leaflets. The number of pods and seeds are lesser than control. Number of leaflets much higher (1.50% SA).
FIGURE PLATE 13 - Selected mutants of *V. faba* in M₃ Generation.
Figure Plate 14 - Chromosomal Abnormalities in V. faba induced by gamma rays (M₁ generation):

Fig A: Diakinesis - Showing 1⁴ (spoon shaped) 4⁴ (10KR)

Fig B: Diakinesis - Showing 1⁴ and 4⁴ (20KR).

Fig C: Metaphase I - 1⁴ and 4⁴. Tetravalent showing early desynapsis (5KR).

Fig D: Anaphase I - Showing fragmented laggard (20KR)

Fig E: Anaphase I - Showing multiple chromatin bridges and unsynchronized separation of chromosomes (30KR).

Fig F: Telophase I - Showing laggard, broken bridge and a fragment (40KR).

Fig G: Prophase II - Showing two micronuclei (40KR).

Fig H: Prophase II - Showing two fragmented laggards (30KR).

Fig I: Metaphase II - One group at equator at metaphase II, while other at prometaphase II (still unorganized on equator) (10KR).

Fig J: Anaphase II - Showing unsynchronized movement of chromosomes, probability of unequal division in one group of separating chromosomes (20KR).

Fig K: Telophase II - 3 groups of chromosomes, dividing chromosomes showing laggard and Inversion bridge (20KR).

Fig L: Telophase II - Showing 3 nucleate condition (two nuclei fused together (40KR).
FIGURE PLATE 14 - Chromosomal abnormalities in *V. faba* induced by gamma rays (M1 Generation).
Figure Plate 15 - Chromosomal Abnormalities in V. faba induced by gamma rays + SA (M1 generation):

Fig A: a - Diplotene - Showing 1 IV + 4 III (5 KR + 2.00%).
b - Diakinesis - Shwong 1 IV + 4 III, tetravalent forming inversion loop (5 KR + 2.00%).

Fig B: Diakinesis - Showing secondary association of 5 IIs + I II (10 KR + 1.00%).

Fig C: a - Metaphase I - Showing 1 stray bivalent and a tetravalent ring (20 KR + 0.25%).
b - Metaphase I - Showing secondary association of 5 IIs + one bivalent free (20 KR + 0.25%).

Fig D: Metaphase I - Showing stickiness and precocious separation of III (10 KR + 1.00%).

Fig E: a - Metaphase I - Showing 6 IIs at equator (5 KR + 1.00%)
b - Metaphase I - Showing 2 IVs + 2 IIs (5 KR + 1.00%).

Fig F: Metaphase I - Showing stickiness in all 6 bivalents (20 KR + 2.00%).

Fig G: Metaphase I - Showing 1 IV forming inversion loop and 4 IIs (30 KR + 0.25%).

Fig H: Metaphase I (late) - 3 III + 2 IIs + 2 stray bivalent.
FIGURE PLATE 15 - Chromosomal abnormalities in *V. faba* induced by Gamma rays + SA (M₁ Generation).
Figure Plate 16 - Chromosomal Abnormalities in *V. faba* induced by gamma rays + SA (*M*₁ generation):

Fig A: Anaphase I - Showing unsynchronized movement of chromosomes and chromatin bridge formation (30KR + 2.00%).

Fig B: Prophase II - Showing a laggard and a bridge (30KR + 1.00%)

Fig C: Metaphase II - Showing inversion bridge and unorganized chromosomes (20KR + 1.00%).

Fig D: Anaphase II - Showing laggard and unequal division of chromosomes (30KR + 1.00%)

Fig E: Anaphase II - Showing unorganized chromosomes forming 3 groups (one group undivided) (30KR + 2.00%)

Fig F: Telophase II - Disoriented chromosomes forming 3 groups + laggard (30KR + 2.00%).

Fig G: Anaphase II - Showing laggard and a bridge (40KR + 0.25%).

Fig H: Telophase II - Showing 6 - nucleate (hexad) condition (30KR + 2.00%).
FIGURE PLATE 16 - Chromosomal abnormalities in *V. faba* induced by Gamma rays + SA (M₁ Generation).
Figure Plate 17 - Chromosomal Abnormalities in *V. faba* induced by γ+ caffeine (*M₁* generation):

Fig A: Prophase I - Diakinesis showing the 1<sup>VI</sup> + 3<sup>II</sup> (5KR + 2.00%)

Fig B: Prophase I - Diakinesis showing 1<sup>IV</sup> + 4<sup>II</sup> (10KR + 0.25%)

Fig C: a - Metaphase I - Showing 6<sup>II</sup> at equator (10KR + 1.00%)
   b - Metaphase I - Showing stickiness among 5<sup>II</sup> + 1<sup>II</sup> (10KR + 1.00%).

Fig D: Metaphase I - Showing one decavalent forming inversion loop and 1<sup>II</sup> free (20KR + 0.25%).

Fig E: Metaphase I - Showing one octavalent forming y shape structure + 2<sup>II</sup> (20KR + 2.00%).

Fig F: Metaphase I - Showing y shaped 1<sup>IV</sup> + 4<sup>II</sup> (40KR + 0.25%)

Fig G: Anaphase I - Showing unsynchronized movement of chromosomes and multiple bridges (20KR + 1.00%).

Fig H: Anaphase I - Showing two laggards (30KR + 1.00%).
FIGURE PLATE 17 - Chromosomal abnormalities in *V.faba* induced by Gamma rays + caffeine (M₁ Generation).
**Figure Plate 18 - Chromosomal Abnormalities in *V. faba* induced by γ+ caffeine (M1 generation):**

**Fig A:**  
- **a:** Metaphase I - $1^\text{IV} + 2^\text{II} + 4^\text{I}$ (40KR + 1.00%)  
- **b:** Metaphase I - $4^\text{II} + 4^\text{I}$ (40KR + 1.00%).

**Fig B:** Telophase I - Showing inversion bridge and a fragment (40KR + 0.25%)

**Fig C:** Prophase II - Showing one micronucleus and stretching of chromatin forming bridge (30KR + 2.00%)

**Fig D:** Metaphase II - Showing unsynchronized disjunction of chromatids and a fragment (10KR + 1.00%).

**Fig E:** Metaphase II - Showing fragment and unsynchronized disjunction (20KR + 2.00%)

**Fig F:** Meta- Anaphase II - Showing chromatin bridge in dividing chromosome set (30KR + 1.00%).

**Fig G:** Anaphase II - Showing disorientation of chromosomes and multipolar orientation (40KR + 2.00%).

**Fig H:** Telophase II - Showing 5 nucleate (Pentad) condition (40KR + 1.00%).
FIGURE PLATE 18 - Chromosomal abnormalities in *V. faba* induced by Gamma rays + caffeine (M₁ Generation).
Figure Plate 19 - Chromosomal Abnormalities in *V. faba* induced by sodium azide (*M*₁ generation):

**Fig A:** Diplotene - Showing stickiness of 4⅞ + 2⅛ free (0.50%).

**Fig B:** Metaphase I - Secondary association of 6⅞ (0.75%)

**Fig C:** Metaphase I - Showing 2⅞ + 2⅛, one tetravalent forming ring (1.25%).

**Fig D:** Metaphase I - Showing 6⅞ and early desynapsis in one bivalent (1.50%).

**Fig E:** Metaphase I (late) - 3 bivalents free + stickiness in other three bivalents (1.25%).

**Fig F:** Anaphase I - Showing unsynchronized movement of chromosomes, and unequal division due to delayed terminalization (1.25%).

**Fig G:** Telophase I - Showing univalent and bivalent as laggards, broken bridge, resulting in unequal division (1.50%).

**Fig H:** Telophase I - Showing 2 laggards (1.00%).

**Fig I:** Prophase II - Showing micronucleus (1.25%).

**Fig J:** Meta-Anaphase II - Showing unsynchronized division (0.75%)

**Fig K:** Anaphase II - Showing disoriented chromosomes and unequal division (1.00%).

**Fig L:** Anaphase II (late) - Showing inversion bridge with fragment and laggards (1.50%).
FIGURE PLATE 19 - Chromosomal abnormalities in *V. faba* induced by SA (M1 Generation).
Figure Plate 20 - Chromosomal Abnormalities in V. faba induced by aniline (M₁ generation):

Fig A: Diakinesis - Showing stickiness of chromosomes (0.75%)

Fig B: Diakinesis - 1⁶ + 1⁴ showing translocation + 1¹ (1.25%)

Fig C: Metaphase I - 1⁴ with inversion ring + 4¹ (1.00%)

Fig D: Metaphase I - Showing 2⁴ + 2¹ (1.75%)

Fig E: Anaphase I - Showing chromatin bridge due to delayed disjunction of a bivalent (1.50%)

Fig F: a & b: Anaphase I - Showing broken bridge and a laggard (2.00%)

Fig G: Telophase I - Two nuclei fused at centre following their polar orientation (1.50%)

Fig H: Telophase I - Showing laggards (1.75%)

Fig I: Metaphase II - Showing fragments & stickiness (1.75%)

Fig J: Metaphase II - Showing disoriented chromosomes and fragments (2.00%)

Fig K: Anaphase II - Showing stretching of chromosomes due to abnormal disjunction (1.50%)

Fig L: Telophase II - 3 nucleate condition and broken bridge (1.75%)

XX
FIGURE PLATE 20 - Chromosomal abnormalities in *V. faba* induced by Aniline (M₁ Generation).
Figure Plate 21 - Chromosomal Abnormalities in *V. faba* induced by gamma rays, SA and aniline ($M_1$ generation):

Fig A: Metaphase I - Showing $1^{III} + 4^{III} + 1^I$ (20KR gamma rays).

Fig B: Metaphase I - $1^{IV} +$ Association of 4 bivalents forming two groups of chromosomes (30KR gamma rays).

Fig C: Metaphase I - Showing $1^{VI} + 3^{III}$ (40KR gamma rays).

Fig D: Metaphase I - $5^{III}$ (ring) + 1 bivalent showing precocious terminalization (1.25% SA).

Fig E: Metaphase I - Showing $1^{IV}$ ring + $4^{III}$ (1.50% SA).

Fig F: Metaphase I - Association of $4^{III}$ + a clump of $2^{III}$, showing uncoiling, non-synapsis in one chromosome (1.75% Aniline).

Fig G: Metaphase I - $3^{III}$ (rod) + $1^{II}$ (ring) + $4^{I}$ (30KR)

Fig H: Metaphase I - Unsynchronization, precocious movement of chromosomes (1.25% SA).

Fig I: Anaphase I - Showing laggards, unequal distribution (1.50% Aniline).

Fig J: Metaphase II - Unsynchronized division of chromatids (1.50% SA).

Fig K: Meta-Anaphase II - One group at metaphase II while other dividing at anaphase II (1.00% Aniline).

Fig L: Telophase II - Showing chromatin bridges (2.00% Aniline).
FIGURE PLATE 21 - Chromosomal abnormalities in V. faba induced by Gamma rays, SA and Aniline (M₁ Generation).