

**VARIABILITY STUDIES IN M₃ GENERATION IN
MUNGBEAN (*Vigna radiata* (L.) Wilczek)**

THESIS

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**Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of**

**MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL BOTANY)
(GENETICS AND PLANT BREEDING)**

**By
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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled "**VARIABILITY STUDIES IN M₃ GENERATION IN MUNGBEAN (*Vigna radiata* (L.) Wilczek)**" or part there of has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola

Date 12/06/2012



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CERTIFICATE

This is to certify that the thesis entitled "**VARIABILITY STUDIES IN M₃ GENERATION IN MUNGBEAN (*Vigna radiata* (L.) Wilczek)**" submitted in partial fulfilment of the requirement for the degree of "**Master of Science in Agriculture (Genetics and Plant Breeding)**" of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **DEVDE SHITAL VASANTRAO** under my guidance and supervision.

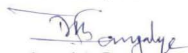
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I am very much indebted to Prof. D. B. Tamgadge, Associate Dean, PGI, Dr. PDKV., Akola for providing necessary facilities during the course of investigation to complete this research work.

I express my deep and profound sense of gratitude towards Prof. D.B. Dhumale, Department of Agricultural Botany, Dr. PDKV. Akola for valuable suggestions and necessary help rendered by him.

I am particularly grateful to Mr. M. R. Wandhare, Assistant professor and Smt. A. W. Thorat Associate professor, Dept. of Agricultural Botany, Dr. PDKV. Akola, for their timely co-operation and valuable suggestion during the course of research work.

I wish to express my cordial thanks to Shri. V.J.Umale, Lab. Attendant and Shri. S.K.Damodar, Department of Agricultural Botany. Dr.PDKV, Akola for their kind cooperation and the help directly or indirectly rendered by them during the period of investigation.

I wish to acknowledge my very special thanks to my well wisher friends Harshal, Namrata, Asmita, Ashwini, Kalpana, Reshma, Harshada, Dipali, Shubhangi, Anita, Priyanka, Madhuri, Shital and Swati for their co-operation in the course of present investigation.

I record my cordial thanks to my "GPB" friends Namrata, Asmita, Sunita, Nilesh, Satyajit, Umesh, Rahul, Santosh, Vamsi, Sudhir, Rohit, and Shrikant. And also Meena, Trupti, Harshal, and Avinash who are in my heart for their excellent company, warmer affections and co-operation for the completion of my research work.

I wish to express my heartfelt and special thanks to my seniors, Prachi, Rupali, Dipali, Santoshi, Jaswini, Achyut Shirao sir, Amol sir and Mayur sir for giving useful suggestions, active help, constant encouragement and devotion in reaching me at this stage.

No words of gratitude can equate the tremendous encouragement of my beloved father Shri. Vasantrao B. Devde and my mother Sau. Annapurna V. Devde whose blessings and inspirations, encouraged and supported me to achieve this goal. I am very thankful to my beloved brother Shri. Amol and Sudhir, sister in law Sau. Vaishali Amol Devde., my sister Sau. Sandhya and Jiju Shivanand Suryawanshi, niece Shambhavi and nephew Gaurav for heart warming affection, moral support and enliven my ability and helped me to complete this task.

I have no words to express my cordial reverence to express my Grand Father Shri. Baburao Devde and my Grand Mother Sau. Saraswati B.Devde for their love, affection and encouragement in reaching me at this stage.

I am also thankful to "Real Computers" and "Shri Graphics", Akola for computerizing the dissertation keenly within time.

I am very much thankful to all authors and researchers, whose literature helped me in organizing my research work on proper line and utilize proper tools for interpretation of the results.

Above all my bow my head before the God almighty without whose blessing it would have not been possible for me to reach at this stage of my life.

Last but not least I want to thank one and all who helped me directly and indirectly for the completion of my research work.

I wish to end this note by expressing thanks to all those whom I unable to recall here and those I might have left unknowingly.

Place : Akola

Date : 12 /06/2011



(DEVDE SHITAL VASANTRAO)

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(D) List of Abbreviations

Abbreviation	-	Expanded Farm
Anova	-	Analysis of variance
%	-	Per cent
/	-	Per
SE(m)±	-	Standard error of mean
CD	-	Critical difference
cm	-	Centimeter
Dr. PDKV	-	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
RBD	-	Randomized block design
viz	-	Namely
<i>et al</i>	-	Et alia (and others)
etc.	-	Etcetera
Fig.	-	Figure
DF	-	Degree of freedom
g	-	Gram
Gy	-	Gray
hrs.	-	Hours
i.e.	-	That is
kR	-	Kilo Roentgen
LD ₅₀	-	Lethal Dose
M	-	Metric tones
No.	-	Number
q/ha	-	Quintal per hectare
Rad.	-	Radiation
⁶⁰ Co	-	Cobalt 60
SD	-	Standard Deviation
t	-	Tonnes

(F) THESIS ABSTRACT

- a) Title of the thesis : "VARIABILITY STUDIES IN M_3 GENERATION IN MUNGBEAN (*Vigna radiata* (L.) Wilczek)"
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- d) Degree to be awarded : M. Sc. (Agriculture)
- e) Year of award of degree : 2012
- f) Major subject : Genetics and Plant Breeding
- g) Total number of pages in the thesis : 65
- h) Number of words in the abstract : 340
- i) Signature of the student : 
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ABSTRACT

An investigation entitled "VARIABILITY STUDIES IN M_3 GENERATION IN MUNGBEAN (*Vigna radiata* (L.) Wilczek)" was conducted during *kharif* 2011 at the field of Pulses Research Unit, Dr. PDKV, Akola. Seeds of AKM-8802, PKV Green gold and AKM-4 of mungbean varieties were exposed to gamma rays doses of 150, 250 and 350 Gy to assess the variability generated for various yield and yield contributing characters in M_3 generation. The bulk seed

of M_2 generation was sown in randomized block design with three replications and the 220 mutants isolated in M_2 were grown in plant to row progenies in non replicated trial for their confirmation. Out of 220 mutants only 28 lines showed true to type breeding behaviour in M_3 generation.

The PCV values were higher than GCV values for all the characters. The characters sprouting percentage, number of pods per plant, number of seeds per pod and 100 grain weight exhibited high GCV and PCV values. High estimates of heritability were recorded for sprouting percentage, number of seeds per pod, number of pods per plant, pod length, 100 grain weight and plant height.

The characters sprouting percentage, number of pods per plant and plant height had high heritability values along with high estimates of genetic advance, indicating the presence of additive gene action and direct selection for such traits is rewarding in crop improvement. High heritability estimates along with low genetic advance values were recorded for pod length, number of seeds per pod and 100 grain weight showing the presence of non additive gene effects.

Apart from variability studies variety and dose wise mean performance was analyzed for 12 characters. In the present investigation treatment 250 Gy was found more efficient and effective in AKM-8802 and AKM-4. And the treatment 350 Gy was found more efficient and effective in PKV Green gold, for various yield and yield contributing traits. It can be expected that modern mutation breeding technologies in combination with refined selection methods applicable to large populations would continue to be of great potential for the improvement of crop plants.

CHAPTER I

INTRODUCTION

1.1 Background information

Green gram (*Vigna radiata* L.) is an important pulse crop grown in India. It is also suitable in all the agro-ecological situations. It belongs to family Leguminosae and sub-family Papilionaceae. It has 12 pairs of chromosomes ($2n=24$). Green gram is originated in India and Central Asia. It is also known as mungbean, moong etc.

Green gram contributes 14 per cent in total area and 7 per cent in total pulses production in India. It has been reported that green gram has been cultivated in India since ancient times. It is believed that green gram is grown in these regions since prehistoric times. It is widely cultivated throughout Asia. It is a protein rich staple food and contains about protein-24.5 per cent, fat-1.2 per cent, fibre-0.8 per cent, minerals-3.5 per cent, carbohydrates-59.9 per cent, calcium-75mg, phosphorus-405mg, iron-8.5mg and small amount of vit. B complex.

It supplies protein requirement of vegetarian population of the country. It is consumed in the form of split pulse as well as whole pulse, which is an essential supplement of cereal-based diet. The mung dal khichadi is recommended to the ill or aged person as it is easily digestible and is a complete diet. It is particularly rich in leucine, phenylalanine, lysine, valine, isoleucine etc.

India is the largest producer of mungbean in the world. It accounts for almost 65 per cent area and 54 per cent production of the world. The area under green gram in India during year 2010-11 was 3.55 mha with production of 1.80 mt having productivity 507 kg/ha. While the area under green gram in Maharashtra during year 2010-11 was 5.54 lakh ha. with production 3.72 lakh ton, having productivity 672 kg/ha. In vidharbha region, it is 2.13 lakh ha area with production 1.34 lakh ton having productivity 629 kg/ha. (Anonymous, 2011a and b).

1.2 Importance of study

The term 'mutation' was first introduced by Hugo de Vries in 1900. But mutations were known to occur in plants and animals much before this time, e.g. a short-legged sheep breed named 'Ancon' was discovered by an English farmer in the 18th century. Mutagenic action of X-ray was discovered by Muller in 1927 on *Drosophilla* and of gamma rays and X-rays by Stadler (1928a) in Barley (*Hordeum vulgare*) and maize (*Zea mays*) (1928b).

The traditional breeding methods for self pollinated crops largely depend on natural variability already present in the crop. Green gram being self pollinated, the naturally existing genetic variability may not be sufficient to achieve desired improvement. Each kind of breeding method involves creation and utilization of genetic variability by means of hybridization, recombination and selection. Due to very small size of flower in mungbean, emasculation and pollination is very difficult and costly. Alternatively, mutation breeding is the best method to create the new genetic variability of a species considerably within a short time.

Gamma rays are the ionizing physical mutagens capable of inducing mutations in plants and animals. They have shorter wave length and therefore possess more energy per photon than X-rays. These rays penetrate up to many cm which are generally produced in a wide range of energies like X-rays.

Number of workers were attracted towards induced mutation studies in different crops. The variation of induced mutations is not merely due to the recombination as in hybridization but they are original and newly created. Induced mutation is used in different ways in plant breeding (Gual, 1963).

1.3 Objectives

The breeding objectives in green gram are to develop varieties with high yield, early maturity, high protein and resistant to diseases and insects-pests. To achieve these objectives and bring about desired improvement in crop the most sophisticated technique of mutation breeding can be exploited by the plant breeders. The present study was undertaken using three genotypes of green gram viz. AKM-8802, PKV Green gold and AKM-4 and one physical mutagen i.e. gamma rays with three doses of 150 Gy, 250Gy and 350 Gy with the following objectives.

1. Confirmation of identified mutants for various yield and yield contributing characters in M₃ generation.
2. To assess the variability generated for various yield and yield contributing characters in M₃ generation.

1.4 Scope and limitation

Mutation is a sudden heritable change brought about in nucleotide base pairs either by addition, deletion or substitution (Gardner and Snustad, 1984). Mutations are of two types, viz. natural mutations and induced mutations. Frequency of natural mutations is very low and hence artificial mutations are induced and genetic variability is best enhanced through the induced mutagenesis with application of various mutagens. In crop improvement, the breeders always look for wide range of variability and stabilized desirable traits. Induction of mutations by artificial means seems to serve the purpose better. Improvement in either single or few polygenically controlled economic traits and quality attributes with a least deleterious effect is not normally achieved by hybridization with shortest possible time. Alternatively, targeted recombination without very much disturbing the yield and quality status of existing well adopted varieties can be achieved within shortest time by induced mutations. Thus this breeding method provides a novel approach to plant breeders for raising the

productivity of crop plants, thus, complementing the conventional methods.

The large number of mutagens both chemical and physical, capable of inducing mutations in plants and animals have been found out. The chemical mutagens include, ethyl methane sulphonate (EMS), methyl methane sulphonate (MMS), diethyl sulphate (DES), hydroxylamine (HA), n-nitroso-n-ethyl urea (NEU), sodium azide (SA) etc. and the physical mutagens include alpha-rays, beta-rays, gamma-rays, X-rays, ultraviolet rays etc.

1.5 Hypothesis

Mungbean is one of the most important pulse crops grown in India. Significant genetic improvement in this crop could not be made in the recent past, which could be attributed to relatively low genetic variability for yield potential in available genotypes. Since induced mutations may result in creating useful variability for yield attributes in the mungbean.

CHAPTER II

REVIEW OF LITERATURE

The mutation research occupies a prominent place in modern and applied genetics. The induction of mutation provides a tool for the creation of new genetic variability in microorganisms and higher plants. The success of any plant breeding programme depends on availability of sufficient genetic variability among genotypes to permit effective selection. Since the discovery of ionizing radiations, extensive work has been undertaken on the effects of the radiation on genetical, cytological, morphological and histological aspects of crop plants. The effects of radiation chiefly X-ray and gamma rays were studied extensively as early as by Petry (1922) and Stein (1922). Muller (1927) was the first to present the conclusive evidence that mutation frequency in *Drosophila melanogaster* was greatly accelerated by X-rays. Stadler (1928 a and b) presented similar findings on barley and maize. Gamma rays are of shorter wavelength and therefore, have more penetrating capacity in tissue (Sparrow and Konzak, 1958).

The induced mutagenesis is the complementary breeding method to the conventional breeding methods. The various mutagens used are X-rays, gamma rays, alpha and beta particles, ultra-violet rays, thermal neutrons etc. The effects of irradiation in respect of different characters in creating genetic variability in leguminous and self pollinated crops were studied by various research workers.

Gamma rays used in biological research work are obtained mainly from two sources Cobalt⁶⁰ and Caesium¹³⁷. The energy is absorbed in the tissue through which they pass, causing an ejection of planetary electrons and thus resulting in ionizations and consequently brought out the chemical reactivity. Genetic alterations may be effected through direct changes in the gene molecules or indirectly through other chemical changes in the cell (Strickberger, 1976).

Khan *et al.* (1973) recorded reduced germination and survival in gamma rays treated seeds of pigeon pea.

Rajput (1974) studied gamma rays irradiated variability in mungbean and observed that there was positive correlation between different quantitative characters and doses except in grains per pod and 100 seed weight. The variability was found to be increased in treated population for each character.

Chowdhary *et al.* (1975) observed significant amount of variability for plant height, number of branches, pods per bunch, peduncle length, and grain yield per plant in irradiated M₂ generation of cluster bean. They also recorded some agronomically induced desirable mutant plants from irradiated material.

Rathnaswamy *et al.* (1978) reported highest heritability estimate for 100-seed weight followed by pod length, while lowest heritability estimate for seed yield per plant. Though pod length and seeds per pod showed high heritability, genetic advance was low for them due to non-additive gene action.

Shakoor *et al.* (1978) observed decreased number of pods per plant in mungbean for 10 to 40 kR gamma rays treatment.

Rumanski and Radkov (1979) reported that gamma irradiated chickpea had high variability along with high heritability estimates and high expected genetic advances for 100 seed weight and yield.

Medhi *et al.* (1980) observed significant variation for ten yield components studied except days to flowering and days to maturity in green gram. Differences between GCV and PCV were small for all the characters.

Bundopadhyay and Bose (1983) treated the black gram variety T-9 with 0.2 percent EMS + 10kR gamma rays and observed large leaves and variation in leaf shape, early flowering and more

number of pod production than in control. In M_2 the plant showed irregular segregation into normal and mutant types. By 0.2 percent EMS+10kR treatment late flowering was induced. They further noticed high pollen sterility compared with poor yield and growth.

Khan (1983) studied pod length, seed yield per plant, 100 seed weight and total seed yield in the M_1 , M_2 and M_3 of *Vigna radiata*. They noticed that the treatment increased the mean value and the range of variation of all traits. Increase in genetic variability, estimates of heritability and genetic advance were found and these varied depending on different traits.

Khan (1984) observed higher mean values and variances treated with gamma rays, EMS, HA and their combinations, for number of pods per plant in M_2 generation of mungbean.

Parida and Singh (1984) reported moderate mean heritability and genetic advance for plant height. The heritability value of yield per plant was lowest among all characters, which indicated that yield per se was highly influenced by environmental conditions as compared to yield components.

Verma and Singh (1984) irradiated dry seeds of green gram with gamma rays at doses of 20, 30, 40 and 50 kR. They recorded increased means for days to maturity, plant height, pods per cluster and 100 seed weight at all the doses except at 50 kR for days to maturity. There was also a decrease in the mean number of seeds per pod, as well as in pods, clusters, seeds and yield per plant.

Rao and Reddy (1985) found gamma rays as the most potent mutagen than DES, EMS and HZ in pigeon pea.

Khan (1988) evaluated 3 quantitative characters viz. number of pods per plant, 100-grain weight and grain yield per plant in cv.G65 after treatment of seeds with gamma rays. Value of heritability and genetic advance were low for all the characters.

Rajput and Sarwar (1988) while studying induced variability in soybean observed positive and negative shifts in the mean values in treated populations for plant height, number of branches per plant, pods per plant, pod length, grains per pod, 100 grain weight and grain yield per plant.

Kulkarni *et al.* (1990) treated seeds of *vigna radiata* varieties PIMS 1 and Pusa Baisakhi with gamma radiations and EMS and selected high yielding M_2 lines which produced M_3 progenies that showed more yield than the control.

Mehetre *et al.* (1990) tabulated the data on germination, survival and 5 morphological traits for plants grown from seed of varieties J781 and S8 treated with 10-50 kR gamma rays in mungbean. The greatest variability was induced at 40 and 50 kR.

Sinha and Bharati (1990) during their variability studies in M_3 mutants of urdbean reported high PCV and GCV values for plant height and low for pod length.

Sarma *et al.* (1991) treated AAU 34 and AAU 39 genotypes of green gram with ethyl methane sulphonate, gamma rays and their combination treatments. The M_1 , M_2 and M_3 progenies were raised and enormous genetic variability was observed in M_2 and M_3 generations. Highest GCV was observed for number of branches per plant followed by plant height.

Singh and Yadav (1991) observed significant increase in pod number for mutants in gamma rays, EMS and combination treatment in green gram.

Charumathi *et al.* (1992) while studying efficiency of early generation selection for induced micro mutations in black gram reported that in the M_3 generation compared with the M_2 , variation was greater for number of branches, pods per plant, pod length, seeds per pod, seed yield per plant, 100-seed weight and protein percentage.

Ahmed and Yaqoob (1993) produced variant genotypes in mungbean following gamma irradiation (10-50 kR). The analysis of the resulting plants grown in the field showed greater variability in all the characters except 100-seed weight. The highest magnitude of variability was observed in plant height and the lowest variability was recorded for pod length.

Murugan and Subramanian (1993) studied gamma - Irradiated (with doses of 20, 30, 40, 50 and 60 kR) M₃ and M₄ generations of two cowpea genotypes, Co 4 and TVX 944-02 E, and investigated for the mean, variability, heritability and genetic advance for 10 yield-related traits. The means of the traits (quantitative) were shifted to the negative or positive directions depending upon the trait, genotype and generation. The genotypes showed increased variance in the M₃ and M₄ for most of the traits, at most of the doses.

Mehetre *et al.* (1994) treated Seeds of soybean varieties Monetta, MACS57, MACS124 and MACS 36 with 10-50 kR gamma irradiation. The mean, genotypic (GCV) and phenotypic coefficients of variation, heritability and expected genetic advance for 7 characters were studied in the M₂ and M₃ progeny. Variations were particularly notable for days to 50% flowering and seed yield/plant for the M₂ and M₃, respectively. Plant height in the M₂ and seed yield/plant in both the M₂ and M₃ had moderate GCV and high heritability. High heritability together with significant genetic advance were noted for plant height (M₂ and M₃), branches/plant and pods/plant (M₂) and seed yield/plant (M₂ and M₃).

Borah and Hazarika (1995) studied genetic variability of 112 exotic genotypes of green gram. High estimates of genotypic variances were recorded only for plant height and number of pods per plant. High estimates of heritability along with high genetic advance and genotypic coefficient of variation values were observed for plant height, number of pods per plant, seed yield per plant, number of clusters per plant and number of secondary branches per plant.

Number of primary branches, days to 50% flowering and days to maturity exhibited low estimates of genetic advance.

Sahu and Patra (1997) reported variations in quantitative characters when seeds of *vigna radiata* cultivars Dhauli and Sujata were treated with ethyl methane sulphonate and sodium azide and it indicated that the PCV estimates were medium (20-50%) for plant height, primary branches, fruiting bunches, pods and seed yield, where as low for the remaining characters studied. GCV were observed for fruiting bunches plant height and primary branches and low for remaining traits. In general, PCV estimates were higher than GCV estimates for all 9 traits studied. Estimates of heritability were moderate to high for all the characters and genetic gain was low for all the characters indicating low potential for further selection.

Das *et al.* (1998) reported high genotypic coefficients of variation for plant height, branches per plant, pods per plant, pod length and yield per plant in 22 genotypes of green gram.

Gautam and Mittal (1998) studied induced mutations in blackgram variety T-9 after seed treatment with gamma rays and EMS. They observed macromutants for – narrow leaves, giant, bushy, dwarf, horizontal, vine type, glabrous, unifoliate, and male sterile and micromutants for – high pod bearing, early maturing, brown seeded, short poded were recorded in M_2 generation. All viable mutants bred true in M_3 generation. Few mutants recorded significantly higher grain yield as compared to normal parents.

Khan *et al.* (1999) while studying M_3 mutants in green gram reported high GCV for number of fertile branches, number of pods and total plant yield and suggested further improvement of these quantitative traits in subsequent generations.

Sarma and Talukdar (1999) reported that seeds of green gram (*vigna radiata*) genotypes AAU 34 and AAU 39 were treated with variable doses of EMS and gamma rays. A large amount of genetic variability was observed in M_2 and M_3 generations.

Tickoo and Chandra (1999) reported that when green gram treated with EMS, NMU, hydroxylamine and gamma rays, mean

values for six characters showed positive shift in M_3 and both interfamilial and overall variances were still significantly higher than respective control values indicating scope for further selection and improvement of characters governed by polygenes.

Chavan *et al.* (2000) treated dry seeds of mungbean variety BM-4 with 10, 15 and 25 kR doses of gamma rays. In M_2 and M_3 the range, variability and variances increased compared to control. Similarly estimates of heritability and genetic advance were greater in treated population. Almost all characters showed positive shift in mean except plant height which had shown negative shift in one or other treated population.

Singh *et al.* (2000) Studied gamma rays and EMS induced genetic variability for quantitative traits in urdbean cv. T-9 and PDU-1. They found that mutagenic treatment had wider values than control. Positive and negative shift in mean were observed for all the quantitative traits in both the cultivators. All the mutagenic treatment influences the mean, range and cv values independently in both the varieties. However the combination of varying doses of gamma rays with EMS 0.02M was found effective for causing induced genetic variability in urdbean cultivators.

Gajraj Singh *et al.* (2001) observed that PS 16 variety of green gram after gamma irradiation and EMS and epichlorhydrin treatment produced increased number of pods per plant, seeds per pod, 100-seed weight and yield. Estimates of genetic parameters showed higher values of phenotypic and genotypic coefficient of variation for number of pods per plant, number of seeds per pod and yield with highest variation recorded for yield.

Longanathan *et al.* (2001) evaluated fifty genotypes of green gram for genetic variability. High phenotypic coefficient of variability indicated the favourable effect of environment for number of clusters per plant and seed yield per plant and high genotypic coefficient of variability suggested substantial amount of genetic variability for number of pods per plant and seeds yield per plant.

Mittal *et al.* (2001) irradiated the Seeds of green gram (cultivars ML-9 and K-851) with gamma rays (20 kR) for the induction of genetic variability in M_2 and M_3 generations. Irradiated ML-9 showed an increase in the genotypic coefficient of variation, heritability and genetic advance for pod length, number of seeds per pod and 100-seed weight; while irradiated K-851 showed an increase in all parameters, except 100-seed weight. The genotypic and phenotypic coefficients of variation, heritability and genetic advance for plant height and number of pods per plant decreased in ML-9.

Uddaraju Chaitanya (2002) while studying variability in mutants of cowpea in M_3 , observed high GCV values for test weight, dry biomass, number of seeds per plant and fresh biomass. The highest PCV value was observed for dry biomass followed by number of seeds per plant, seed yield per plant and fresh biomass.

Khan and Wani (2003) evaluated mutants of mungbean cv. Pusa Baisakhi to determine the selection response in the M_3 generation. Increase in yield concurrent with the increase in mean values of fertile branches and pods per plant was noticed. Estimates of genetic variation for yield and yield components were higher. Correlation between various character pairs of the mutants showed positive and significant relationships with fertile branches, pods and seed yield per plant.

Maheshwari *et al.* (2003) two soybean (*Glycine max*) cultivars, i.e. JS-80-21 and Bragg, were subjected to gamma radiation at doses of 15 and 20 kR to induce genetic variability and to isolate useful mutants in the M_1 and M_2 generations. Increased variability was observed for most of the 13 quantitative characters studied. High-yielding mutants were isolated from Bragg treated with 15 kR of gamma radiation.

Patil *et al.* (2003) studied the genetic variation in the M_2 and M_3 generations of soybean cultivars Monetta and MACS-13 treated with 0.3 or 0.6% ethyl methane sulfonate, or 25 kR gamma rays. Genotypic difference was determined in terms of plant height, number of branches, number of pods and seed yield/acre. Among the 240

plants examined from the M_2 generation, 37 were selected and used to produce the M_3 population. Among the 1472 plants from the M_3 generation, 196 were high-yielding.

Das and Misra (2005) mutated the green gram cv. Pusa Vishal using 4 doses each of 3 mutagens, gamma rays (15, 30, 45 and 60 kR), ethyl methane sulfonate (EMS; 0.15, 0.30, 0.45 and 0.60%) and N-methyl-N-nitrosoguanidine (NG; 0.005, 0.010, 0.015 and 0.020%) and studied M_1 and M_2 generations. The genetic coefficient of variation and heritability estimates in the populations varied with the mutagens, their dose and traits studied. Genetic advance estimates showed that selection in many treatment populations would be effective in bringing out considerable improvement in many traits. Considering all these, the mutagenic treatments with 45 kR gamma-rays, 0.30 or 0.45% EMS and 0.01% NG appeared to be the most effective for induction of more micro-mutations with positive effects on direct yield components.

Mathew *et al.* (2005) treated mungbean cv. PUSA 9072 with ethyl methane sulfonate (EMS) at different concentrations. Heritability was high for days to maturity, pod length and plant height. However, high estimates of genotypic coefficient of variation and genetic advance were observed for seed yield per plant, pods per plant, clusters per plant, plant height and 100-seed weight in M_3 generation.

Mensah *et al.* (2005) treated the cowpea cultivars (CV 1AR48 and 1T2246) with ^{60}Co gamma irradiation and evaluated for 4 generations. Data were recorded for germination, survival percentages and number of pods per plant, 100-seed weight and number of seeds per plant. Higher genotypic coefficient of variability, heritability and genetic gain was observed in the number of pods per plant and seeds per plant.

Nandanwar *et al.* (2005) treated seeds of 3 varieties of soybean viz. Bragg, TAMS-38 and AMS-2000-1-1 with 150, 250 and 350 Gy doses and M_1 , M_2 generations were raised. In M_2 a dose dependant decrease was noticed in germination percentage, plant

height and plant survival while number of branches was not affected significantly. Some useful mutants were identified such as high yielding mutant, extra early type mutant and high branched type mutant were recorded in 250 Gy in all the three varieties. While non shattering mutant in 350 Gy dose was observed in variety TAMS-38. In general 250 Gy dose was found more effective in inducing wide range of morphological mutations in all the three varieties.

Tadele *et al.* (2005) reported the nature and magnitude of induced polygenic variability following gamma rays treatment of 3 Kabuli type chickpea lines in M_2 and M_3 generations. M_3 generation mutant lines gave significantly higher seed yield compared to the control. High values of broad sense heritability coupled with high-expected genetic advance were observed for seed yield per plant, pods per plant and seeds per plant.

Khan *et al.* (2006) observed the mutagenic effect of ethylmethane sulphonate (EMS) and sodium azide (SA) on three quantitative characters viz., plant height, days to flowering and days to maturity in mungbean [*Vigna radiata* (L.) Wilczek]. Mean values shifted in negative directions for all the characters whereas genetic parameters differed in different mutagenic treatments. Enhancement in range of genetic variability for quantitative characters in M_2 and M_3 generations of the treated populations was indicative of the wider scope of selection.

Khan and Wani (2006a) studied the genetic variability induced by ethyl methane sulfonate (EMS) on the number of fertile branches per plant, number of pods per plant, 100-seed weight and yield per plant in M_2 and M_3 generations of green gram (*Vigna radiata*) cv. Asha. A significant shift towards the positive direction was observed in the mean values of all the quantitative traits studied. High values of heritability and genetic advance over the control indicated the possibility of inducing desirable mutations for polygenic traits accompanied with effective selection in M_2 and later generations. Yield per plant was positively correlated with various yield contributing traits, but did not show any association with seed protein content.

Khan and Wani (2006b) Evaluated the extent of genetic variability in three quantitative traits, i.e. plant height and days to flowering and maturity in the M_2 and M_3 generations following mutagenesis with methyl methane sulfonate (MMS) and sodium azide (SA) in mungbean (*Vigna radiata*) cv. T 44. A higher genetic variability for various quantitative traits was recorded in the M_2 in comparison to the M_3 generation, indicating that potential gain could be achieved through selection in early generation.

Kumar and Mishra (2006) irradiated seeds of black gram type 9 variety with 10, 20, 30, 40 and 50 kR gamma radiation dry or soaked in water for 6 h. Seeds obtained from surviving M_1 plants were sown and the M_2 generation was observed. The evaluated characters included: pod number/plant, seed number/pod, 100-seed weight and yield/plant. Gamma radiation applied at 30 and 20 kR under dry seed condition, and 50 and 40 kR under soaked conditions was effective in inducing genetic variation for grain yield and yield characters.

Tah (2006) observed in *Vigna radiata* significant changes with wide range of variations identified in yield and its contributing characters like number of pods/plant, cluster of pods/plant, number of leaves/plant, primary and secondary branches/plant, internode length and plant height. Similarly, highest plant height at 20 kR internode length and primary branches/plant at 30kR were observed.

Wani and Khan (2006) noticed a significant increase in mean values of the fertile branches per plant, pods per plant and seed yield per plant, in mutants of mungbean (*Vigna radiata* (L.) Wilczek) – a self fertilized crop. Estimates of genetic parameters (genotypic coefficient of variation, heritability and genetic advance) for the yield and its components were higher than the control in two generations. The increased genetic variability for these traits provided great scope for further selection.

Das *et al.* (2007) gamma rays induced suspected variants from M_2 generation of cv. K-851 and cv. Sonamung were advanced to M_3 generation. Analysis showed significance variation for pods per plant, pod length, 100 seed weight and yield per plant. Significant

increase for yield and its attributing traits were observed from the families mostly derived from 30 kR and 40 kR treatments.

Khan and Kouser Parveen (2007) studied the Induced genetic variability for yield and its contributing traits in mungbean cv. NM-1 in the M_3 generation. Observations were recorded on fertile branches per plant, pods per plant, 100-seed weight and seed yield per plant. Estimates of mean and genetic parameters indicated that selection for desirable types should be made in the M_3 and later generations. Estimates of correlation coefficient revealed positive and significant association between various character pairs of the M_3 high-yielding mutants.

Wani and Khan (2007) treated seeds of mungbean (*Vigna radiata* (L.) Wilczek) var. NM-1 with hydrazine hydrate (0.01% and 0.02%) and data were recorded on biological damage in M_1 and on quantitative characters in M_2 and M_3 generations. Quantitative characters like fertile branches/plant, pods/plant, 100-seed weight and total plant yield expressed high values of genotypic variability and genetic advance in M_2 and M_3 generations, suggesting the possibilities of effective selection and further improvement of these characters in future generations.

Kumar *et al.* (2008) investigated the effect of the amount of genetic variability induced by 10, 20, 30, 40 and 50 kR doses of gamma-rays in M_2 generation of mungbean under dry and water-soaking (for 6 h) seed treatments. The medium doses of gamma rays (30 and 20 kR) under dry treatment and higher doses (40 and 50 kR) under soaked treatment were the most effective to induce genetic variability for grain yield and its attributing characters.

Nandanwar and Manjayya (2008a) two varieties of soybean viz. JS-71-05 and JS-93-05 were treated with 150 Gy, 250 Gy and 300 Gy doses of gamma rays and M_1 generation was raised and it is harvested on single plant basis. M_2 generation was raised from the seed harvested in M_1 generation and the frequency and spectrum of chlorophyll and morphological mutations were scored. Observations were recorded on 900 selected individual plants for stress and disease

resistance along with quantitative characters. Out of 900 mutants only 6 mutants were identified for stress resistance and yield and they are advanced to M₃ generation for further study and confirmation.

Nandanwar and Manjayya (2008b) identified a mutant M-21 in M₅ generation. The mutant M-21 released and notified under the name of TAMS-98-21 i.e. Tromby Amravati Soybean -98-21. The seed of TAMS-98-21 possesses high oil content and protein content as compared to JS-335.

Nandanwar *et al.* (2008) soybean variety "Bragg" was subjected to gamma rays treatment with 150, 250 and 350 Gy doses with an objective to induce variability for oil and protein quality. M₂ population was raised and the mutants were selected on the basis of higher number of pods, more number of branches, 100-seed weight, earliness with resistance to shattering. 31 M₂ mutants with specific characters were advanced to M₃ and M₄ generation for confirmation of desirable mutations for quality parameters.

Singh and Rao (2008) estimated the genetic variability induced by gamma irradiation (30, 40, 50 or 60 kR) in green gram cultivars TARM 1 and Sujata in M₁ and M₂ generations. Observations on 7 quantitative traits (plant height, number of bunches per plant, number of pods per plant, pod length, number of seeds per pod, 100-seed weight, and single plant yield) were recorded and the mean, range and coefficient of variation (CV) for these traits were estimated. Induced variability was greatest for pod length, number of pods per plant and number of seeds per pod. Sujata appeared to be more promising than TARM 1 due to the induction of positive mutations in important economic traits.

Tah (2008) studied the multiple leaflets in mungbean and investigated the effects of multiple leaflets to the desirable quantitative characters through correlation studies. Increase in multi-foliation may increase the biomass production, which could make a positive impact on seed yield by increasing the transfer of assimilates from source to sink. Higher values for phenotypic and genotypic coefficient of variability for number of leaves suggested that there was a possibility

for improving seed yield through direct selection for number of leaves with pods/plant and plant height.

Arulbalachandran and Mullainathan (2009) evaluated variability on quantitative characters such as plant height, number of branches/plant, number of leaves/plant, number of fruit clusters/plant, number of pods/plant, number of seeds/pod, yield/plant and 100 seed weight of black gram in M_2 generation by the effect of gamma rays. The results showed high genetic variability, heritability and genetic advance with significant enhancement (P 0.05 and P 0.01) in growth and yield traits. The results had showed significant enhancement in yield and related traits. It indicates that improvement in quantitative traits would be possible through gamma rays.

Arulbalachandran *et al.* (2009) attempted to improve some of the quantitative traits of black gram by using gamma rays irradiation. The study revealed that gamma irradiation induced and enhanced the quantitative traits at 60 kR evident to improving of black gram with genetic variation.

Barshile *et al.* (2009) used three mutagens, sodium azide (SA), ethyl methane sulphonate (EMS) & gamma radiation (GR) employed to induce genetic variability in chickpea cultivar Vishwas. Different kinds of mutations *viz*, chlorophyll mutations (chlorine and xantha), pod mutations (large, long, small, roundish, narrow and elongated), seed mutations (wrinkled, bold, dark brown, bold dark brown), flower mutations (2 tier and open), morphological mutations (bold seeded, small pod, early and tall), were observed in M_2 generation. Induced mutant lines showed both positive and negative increasing quantitative trait.

Jain and Khandelwal (2009) in *Vigna mungo* estimated genetic parameters of variation for all the characters in order to assess the selection criteria for improvement of seed yield per plant and early maturity. High heritability along with relatively high genetic advance as percentage of mean were recorded for number of pods per plant (68.7, 3.47), plant height (65.5, 17.1), number of seeds per pod (39.1, 11.5)

and seed yield (55.7, 27.5). This indicated that selection for these quantitative traits in further generation would be highly responsive.

Khan and Goyal (2009) induced mutations in two mungbean varieties, K-851 and PS-16 using EMS and gamma rays as mutagens. Selection studies were conducted to improve the yield and to generate genetic variability in different quantitative traits viz., fertile branches per plant, pods per plant and seed yield per plant. Mean values in traits increased significantly over the controls and genetic parameters were recorded higher for the mutants isolated in M_5 generation. High values of heritability and genetic advance for the mutants indicated that further improvement could be made in next generations.

Arulbalachandran *et al.* (2010) studied variability caused by induced mutation, which enhanced the productivity. They evaluated variability for quantitative traits such as plant height, number of branches/plant, number of leaves/plant, number of fruits/cluster, number of pods/plant, seeds/pod, yield/plant and 100 seeds weight in M_2 and observed high genetic variability, heritability and genetic advance with significant enhancement in growth and yield traits in black gram.

Azad (2010) investigated the yield and yield components of isolated mutants of a mungbean variety Asha in M_3 generation. All these mutants isolated for higher plant yield had also shown higher values for the number of fertile branches and pods per plant as compared to control. Coefficient of variations (Phenotypic and genotypic), heritability and the genetic advance for the number of fertile branches, number of pods and the total plant yield also revealed a higher value in all the mutants.

Khan and Tyagi (2010) studied variability induced by gamma rays and ethyl methane sulphonate (EMS) for nine quantitative traits of soybean. The estimates of coefficient of variability for all the characters were high in all the mutagenic treatments. The high coefficient of variability was also accompanied by moderate to high heritability for plant height, number of pods per plant, number of seeds

per pod and seed yield. Low to moderate heritability was observed for pod length and 100 seed weight and genetic advance as percent of mean for different characters in various mutagenic treatments.

Pavada *et al.* (2010) studied the effectiveness and efficiency, yield parameters and statistical analysis for M₂, M₃ and M₄ generations of Soybean (*Glycinemax* (L.) Merrl.) using gamma rays treatment. In most of the treatments, positive shift was recorded. The statistical analysis such as variability, heritability and genetic advance as per cent of mean was recorded high for treatments than the untreated plants for all the generations. 50kR of gamma rays treatment was effective than the other mutagenic treatments compared to control.

Selvam *et al.* (2010) studied the extent of variability existed in the rice fallow blackgram varieties namely VBN3 and ADT 3 after induction of mutation through chemical mutagens namely EMS and colchicine. The PCV and GCV showed significantly higher values in yield component characters such as number of branches per plant, number of pods per cluster, number of pods per plant and seed yield per plant in M₂ generation. The yield attributing traits like number of branches per plant, number of pods per cluster, 100 seed weight and seed yield per plant recorded high heritability coupled with high genetic advance as per cent of mean in M₂ generation.

Bhosale and Hallale (2011) exposed the seeds of black gram [*Vingo mungo* (L) Hepper] variety TPU-4, to gamma rays doses at 10, 20, 30, 40, and 50kR. Wide range of chlorophyll and viable morphological mutations were isolated in M₂ generation. Mutant characters were grouped as Chlorophyll, leaf, and pod mutants. Chlorophyll mutations include albino, coppery leaf, light green leaf, variegated leaf, waxy leaf, xantha leaf. Leaf mutations were lanceolate, narrow rugose leaf, round cuneate leaf, unifoliate, and tetrafoliate leaf. Pod mutations were lobed and hairy pods. Higher chlorophyll mutation rate was observed with gamma rays dose of 30kR.

Gita Patil and Wakode (2011) treated two varieties of soybean (*Glycine max* (L) Merrill) viz., JS-335 and PKV-1 with various doses of physical (gamma rays) and chemical (EMS) mutagens.

Results indicated that higher doses were more effective in all the three generations (M_1 , M_2 , and M_3). However, the M_1 showed more pronounced reduction in germination and survival than M_2 and M_3 . The increase in pollen sterility was more in cv. PKV-1 indicating its more sensitivity as compared to cv. JS-335.

Kulthe and Kothekar (2011) investigated the mutagenic effects of different concentrations of sodium azide (0.01%, 0.02% and 0.03%) on chickpea (*Cicer arietinum* L.) varieties Akash and Vishal. The characters studied included days to flowering, days to maturity, plant height, number of pods per plant, number of seeds per plant and hundred seed weight in M_2 and M_3 generations. Both negative and positive shifts in mean values were recorded as a result of the chemical treatment. The results indicated the possibilities of evolving higher yield variants through proper selection. Thus, economic traits like days to maturity, number of pods per plant, number of seeds per plant and hundred seed weight in M_3 generation offered scope for selection and improvement.

Pathania *et al.* (2011) irradiated two varieties of chickpea namely HPG-17 and Himachal chana-1 with 30kR, 40kR, 50kR doses of gamma-rays to induce variability for yield and related traits. Significant shift in mean values for quantitative traits was observed in M_2 and M_3 generations. The magnitude of variability was more in 30kR treated population of HPG-17 and 40kR treated population of Himachal chana-1. High heritability coupled with high genetic advance were observed for plant height, biological yield and seed yield per plant in HPG-17 and for pod bearing branches per plant in Himachal chana-1.

Satpute and Suradkar (2011) used the seed material of groundnut (*Arachis hypogaea* L.) variety TAG-24 and reported that the mutagenized population showed significantly higher variability in the M_2 and M_3 generations. Mutations affecting seed coat colour were detected in M_3 generation. Highest mutation frequency was induced by 15 kR of gamma rays. The seed coat colour mutant showed diverse shades of colour.

Wani (2011) evaluated polygenic variability induced by gamma rays, EMS and their combinations in chickpea var. Pusa-372. For days to flowering, days to maturity and plant height, mean values significantly decreased, whereas, for yield and yield contributing traits, mean values increased significantly in M_3 generation. A considerable amount of variability was induced in the treated populations in M_2 generation. Heritability and genetic advance values were increased in M_3 for all yield contributing traits such as, number of pods per plant, number of seeds per pod, 100-grain weight, grain yield per plant and pod length.

CHAPTER III

MATERIAL AND METHODS

The present investigation, "Variability studies in M_3 generation in mungbean (*Vigna radiata* L.)" was conducted at the field of Pulses Research Unit, Dr. PDKV, Akola during *kharif* 2011. The details of materials used and statistical procedures followed for the present study are given below.

3.1 Materials

For the present study three released varieties of mungbean viz., AKM-8802, PKV Green gold and AKM-4 were used. These varieties were collected from Pulses Research Unit Dr.PDKV Akola.

Table 3.1: Main features of selected varieties

Genotypes	Year of Release	Days to maturity	100 Seed Weight(g)	Features
AKM-8802	2000	61-63	4.1	Lodging and Yellow mosaic disease susceptible
PKV Green gold	2007	67-72	3.43	Short pod length and small grain size
AKM-4	2009	67-69	3.08	Short pod, medium grain and No shininess

3.1.1 Irradiation

Eighty grams seeds of each variety was irradiated with 150, 250 and 350 Gy Gamma rays at the BARC (Bhabha Atomic Research Centre) Trombay, Mumbai on 27th Feb, 2010.

Table 3.2: Details of Treatments

Treatment code	Variety	Description of Treatment.
T1	AKM-8802	Control (0Gy)
T2	AKM-8802	Irradiation with 150Gy
T3	AKM-8802	Irradiation with 250Gy
T4	AKM-8802	Irradiation with 350Gy
T5	PKV Green gold	Control (0Gy)
T6	PKV Green gold	Irradiation with 150Gy
T7	PKV Green gold	Irradiation with 250Gy
T8	PKV Green gold	Irradiation with 350Gy
T9	AKM-4	Control (0Gy)
T10	AKM-4	Irradiation with 150Gy
T11	AKM-4	Irradiation with 250Gy
T12	AKM-4	Irradiation with 350Gy

3.1.2 M₁ generation

The treated seeds along with one control for each genotype were sown to raise M₁ generation in replicated trial, at the research field of Department of Botany, Dr.PDKV, Akola on 5th March, 2010 by Mr.A.B.Shrirao (M.Sc. student). The M₁ generation was observed for different parameters besides population screened for chlorophyll mutants. Seeds from each plant of M₁ generation was harvested separately.

3.1.3 M₂ generation

The M₂ generation was raised in *kharif* 2010 (sown on 2nd July 2010). Plant to row progenies were raised from all the harvested seeds from each treatment. The treated populations were carefully screened for chlorophyll mutations where as viable chlorophyll mutations were scored throughout the life period of the plants. The spectrum of chlorophyll and morphological mutations were scored treatment wise to study mutagenic effectiveness and efficiency of each treatment, by Mr.A.B.Shrirao (M.Sc. student).

3.2 Methods

3.2.1 M₃ generation

In *kharif* 2011, on 10th July, all the harvested seeds from each treatment from M₂ generation were sown to raise M₃ generation in replicated trial using Randomized Block Design. The sowing was undertaken on the well leveled piece of land at the field of Pulses Research Unit, Dr. PDKV, Akola.

3.2.2 Experimental details of M₃ generation

1. Experimental Design : Randomized Block Design (RBD)
2. Replications : Three
3. Treatments : 9 + 3 control
4. Spacing : 45cm x 10cm
5. Gross plot : 3.00m x 1.80m
6. Net plot : 3.00m x 0.90m

The recommended cultural practices were followed throughout the crop growth period. The M₃ generation was observed for different parameters. Observations were recorded for different characters on randomly selected 5 plants for each treatment.



3.2.3 Confirmation of identified mutants

The two hundred twenty mutants identified and isolated in M_2 generation were sown to raise M_3 generation. Plant to row progenies were raised from the seeds of each mutant.

3.2.4 Experimental details

1. Experimental design : Un-replicated
2. Treatments : 9 + 3 control
3. Spacing : 45cm x 10cm
4. Plot : Plant to row progenies
5. Row length : 3.00 m

Observations were recorded for different characters on randomly selected 5 plants for each treatment and confirmation was carried out. Total number of mutants were recorded and classified as below.

- i. High yielding
- ii. Bold seeded
- iii. Leaf mutants
- iv. Branching
- v. Dwarf mutants
- vi. Lodging resistance

Confirmation of these mutants was carried out for all the yield and yield contributing characters.

3.3 Observations recorded

3.3.1 Germination percentage

The emergence of cotyledonary leaves above the ground surface was taken as indication of germination. The observations were recorded after 10 days of sowing. The germination percentage was worked out for all treatments including control as per the formula given below.

$$\text{Germination (\%)} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

3.3.2 Days to 50 percent flowering

Number of days required for the commencement of flowering to fifty percent plants in each plot was recorded.

3.3.3 Plant height (cm)

Height of plant at maturity was recorded in centimeters from the base of plant to point of initiation of terminal inflorescence of randomly selected five plants.

3.3.4 Number of branches per plant

Number of branches located on main axis and primary branches were recorded on five randomly selected plants from each plot.

3.3.5 Number of pods per plant

Total number of pods on individual plants were counted and recorded.

3.3.6 Pod length (cm)

Length of pod in centimeters from base of the pod to its tip was recorded by taking five pods of each plant.

3.3.7 Number of seeds per pod

Number of seeds per pod of five randomly selected pods from each observational plant was recorded by counting number of seeds in the pod and average was worked out.

3.3.8 Grain yield per plant (g)

The pods from each randomly selected plant were threshed separately and weight of grain per plant was recorded in grams.

3.3.9 100 grain weight (g)

Hundred seeds were counted and weight was recorded in grams.

3.3.10 Number of days to maturity

Number of days were recorded when 50 percent plants in each plot were ready for harvest.

3.3.11 Final plant count

Total number of plants at the time of harvest in each plot was recorded.

3.3.12 Sprouting percentage

Sprouting percentage was recorded by giving water spray on the dried pods. The experiment was conducted in laboratory and sprouting percentage was recorded.

3.4 STATISTICAL ANALYSIS

The mean values worked out from the measurements recorded on five randomly selected plants for different characters were used for statistical analysis. The following statistical parameters were used for presentation of data on different quantitative attributes.

3.4.1 Analysis of variance

The data available on individual characters was subjected to the method of analysis of variance commonly applicable to the Randomized Block Design (Panse and Sukhatme, 1988). The analysis of variance was done as given below:

Table 3.3: ANOVA

Sources of variation	d.f.	M.S.	Expected M.S.
Replications	(r-1)	RMS	$\sigma^2e + g\sigma^2r$
Genotypes	(g-1)	GMS	$\sigma^2e + r\sigma^2g$
Error	(r-1) (g-1)	EMS	σ^2e

(Panse and Sukhatme, 1988)

Where,

- r = number of replications
- g = number of genotypes
- MS = mean squares
- σ^2e = environmental variance
- σ^2g = genotypic variance
- σ^2r = replication variance

The genotypic mean squares (GMS) were tested against error mean sum of squares (EMS) by 'F' test for $n_1 = (g-1)$ and $n_2 = (r-1) (g-1)$ degrees of freedom.

3.4.2 Estimation of means and range

The mean value for each character was worked out by dividing sum of all observations by number of observations

$$\bar{X} = \frac{\sum X_i}{n}$$

Where,

$\bar{X}$ = Mean of the character

$\sum X_i$ = summation of all observations

n = number of observations

Range: It was recorded as the lowest and highest values from mean of each character.

$$\text{Coefficient of variation (C.V.)} = \frac{\text{S.D.}}{\bar{X}} \times 100$$

Where,

$$\text{Standard deviation (S.D.)} = \sqrt{\frac{1}{n} \sum (X - \bar{X})^2}$$

3.4.3 Estimation of components of variation

The phenotypic, genotypic and environmental variances were calculated by utilizing the respective mean square values from the variance table.

a) Environmental variance

$$\sigma^2_e = \text{EMS}$$

b) Genotypic variance

$$\sigma^2_g = \frac{\text{GMS} - \text{EMS}}{r}$$

c) Phenotypic variance

$$\sigma^2_p = \sigma^2_g + \sigma^2_e$$

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of squares

r = Number of replications

3.4.4 Estimation of coefficients of variation

The genotypic and phenotypic coefficients of variations were calculated as per the formulae given by Burton and Devane (1953).

a) Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

Where

$\sigma^2 g$ = Genotypic variance

$\bar{X}$ = Mean of the character

b) Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{\sigma^2 p}}{\bar{X}} \times 100$$

Where

$\sigma^2 p$ = Phenotypic variance

$\bar{X}$ = Mean of the character

3.4.5 Estimation of heritability ($h^2 b$)

Heritability in broad sense was estimated for various characters by the formula suggested by Lush (1945).

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

3.4.6 Estimation of genetic advance (GA)

The genetic advance was calculated in percent by the formula suggested by Johnson *et al.* (1955).

a) $GA = \frac{\sigma^2 g}{\sigma^2 p} \times \sigma p \times K$

b) GA as percentage of mean

$$GAM = \frac{GA}{\bar{X}} \times 100$$

Where,

σ^2g = Genotypic variance

σ^2p = Phenotypic variance

σp = Phenotypic standard deviation

K = Selection differential at 5 per cent selection intensity (2.06)

$\bar{X}$ = Mean of the character

3.4.7 Estimation of standard error, standard error of difference and critical difference

a) Standard error of mean

$$SE(m) = \frac{\sqrt{\sigma^2e}}{r}$$

b) Standard error of difference between two means was calculated as
S.E. of difference of mean SE (d)

$$S.E. \text{ of difference of means} = SE(m) \times \sqrt{2}$$

c) Critical difference between any two means was calculated as:

$$C.D. = SE(d) \times \text{table 't' value at error degrees of freedom.}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was undertaken to study the genetic variability, heritability and genetic advance in M_3 generation of green gram. The observations were recorded on 12 yield and yield contributing characters at various stages of crop growth. The results obtained are described as below –

4.1 Experimental Results

4.1.1 Confirmation of induced macromutations in M_3 generation.

In M_3 generation, plant to row progenies were grown from 220 selected M_2 plants for their confirmation. Out of these 220 lines, only 28 lines showed true to type breeding behaviour in M_3 generation and remaining lines showed segregation for the selected characters. The characters of 28 mutant lines which were confirmed in M_3 generation are given in Table 4.1.

4.1.2 Analysis of variance

The analysis of variance was carried out for all the characters to know whether the mutants and control varieties differed significantly among themselves for the characters studied. Analysis of variance for these characters is presented in Table 4.2.

The analyzed data indicated that all the characters were found to be highly significant at 1 % probability level and also it revealed significant treatment sum of squares for all the twelve characters studied except for the final plant count. Sprouting percentage (585.96) showed maximum treatment sum of squares followed by number of pods per plant (149.52). 100 grain weight (1.09) showed minimum treatment sum of squares followed by number of branches per plant (1.27), grain yield per plant (2.92) and pod length (3.80). It therefore, appeared that all the mutants and control varieties

under study differed significantly for yield and yield contributing characters.

Table 4.1 Confirmation of induced macromutations in M₃ generation

Sr. No.	Parental variety	Dose in which Mutant isolated	Desirable character(s) possessed by mutants
1.	AKM-8802	250 Gy	Dwarf- 35 cm
2.	AKM-8802	250 Gy	Lodging resistant
3.	AKM-8802	250 Gy	High yielding with more branching
4.	AKM-8802	350 Gy	Vigorous growing with more branching
5.	AKM-8802	350 Gy	Tall, more branching and lodging resistant
6.	AKM-8802	350 Gy	Small pod size
7.	Green gold	150 Gy	Tall-85 cm
8.	Green gold	150 Gy	Lodging resistant
9.	Green gold	250 Gy	Quadrafoliate
10.	Green gold	250 Gy	Broad leaf mutant
11.	Green gold	250 Gy	Early maturing i.e. within 60 days
12.	Green gold	250 Gy	High yielding with more branching
13.	Green gold	250 Gy	Tall -75 cm and lodging resistant
14.	AKM-4	150 Gy	Pentafoliate
15.	AKM-4	150 Gy	High yielding with 70 pods, more branching
16.	AKM-4	150 Gy	High yielding with 52 pods and pentafoliate
17.	AKM-4	250 Gy	Lodging resistant
18.	AKM-4	250 Gy	Lodging resistant with tall and erect growing
19.	AKM-4	250 Gy	High yielding with 55 pods

20.	AKM-4	250 Gy	High yielding with 53 pods
21.	AKM-4	250 Gy	More branching with 6-7 branches
22.	AKM-4	250 Gy	Tall sterile mutant -100 cm
23.	AKM-4	250 Gy	Early maturing i.e. within 58 days
24.	AKM-4	350 Gy	Dwarf with more branching
25.	AKM-4	350 Gy	High yielding with 6-7 branches
26.	AKM-4	350 Gy	Erect growing mutant
27.	AKM-4	350 Gy	Crumpled leaf mutant
28.	AKM-4	350 Gy	Early maturing i.e. within 56 days

Table 4.2 Analysis of variance for various yield and yield contributing characters in M₃ generation

Sr. No.	Characters	Mean sum of squares		
		Replications (2)#	Treatments (11)#	Error (22)#
1	Germination percentage	18.67	63.69**	14.02
2	Days to 50% flowering	17.12	28.45**	6.49
3	Plant height (cm)	3.94	106.29**	10.21
4	No. of branches per plant	0.19	1.27**	0.34
5	Pod length (cm)	0.10	3.80**	0.26
6	No. of pods per plant	0.41	149.52**	4.83
7	No. of seeds per pod	0.28	16.96**	0.38
8	Grain yield per plant (g)	0.08	2.92**	0.82
9	100 grain weight (g)	0.12	1.09**	0.08
10	No. of days to maturity	0.33	49.01**	11.65
11	Sprouting percentage	3.52	585.96**	6.83

** Significant at 1% probability

Values in parenthesis indicates degrees of freedom

4.1.3 Mean performance

Variety and dose wise mean performance for the 12 characters under study are presented in Table 4.3.

4.1.3.1 Germination percentage

In M₃ generation, germination was found to be decreased in all the treatments as compared to respective control in all the genotypes. From Table 4.3 it is observed that decrease in germination was found with increase in doses of gamma rays. In AKM-8802 maximum reduction in germination was recorded in 350Gy dose (T4-58.83%) followed by 250Gy dose (T3-64.96%) and 150Gy dose (T2-65.70%) as compared to control T1 (72.10%). PKV Green gold and AKM-4 have shown similar reduction in germination. 350Gy dose (T8-57.63%) as compared to control T5 (69.96%) in PKV Green gold and 350Gy dose (T12-59.96%) followed by 250Gy dose (T11-61.36%) and 150Gy dose (T10-62.03%) as compared to control T9 (68.23%) in AKM-4 respectively.

4.1.3.2 Days to 50% flowering

In AKM-8802, from Table 4.3 it showed 150Gy dose (T2-29.66) and 250Gy dose (T3-31.66) was earliest for days to 50 percent flowering as compared to control T1 (35.66) and increase in days to 50 per cent flowering was observed in 350Gy dose (T4-38.33). In PKV Green gold, 150Gy dose (T6-37.00) and 250Gy dose (T7-37.33) were earliest for days to 50% flowering than control T5 (38.06) and 350Gy dose (T8-38.33) showed increase in days to 50% flowering. In AKM-4 250Gy dose (T11-37.73), 150Gy dose (T10-38.33) and 350Gy dose (T12-38.67) were early for days to 50 per cent flowering than control T9 (40.33).

Table 4.3 Mean performance of the genotypes for various yield and yield contributing characters in M₃ generation

Genotypes	Treatment code	Treatments	Germination (%)	Days to 50% flowering	Plant height (cm)	No. of branches / plant	Pod length (cm)	No. of pods / plant	No. of seeds / pod	Grain yield / plant (g)	100 grain weight (g)	Final plant count	No. of days to maturity	Sprouting (%)
AKM-8802	T1	Control	72.10	35.66	62.00	4.46	7.66	19.20	11.35	6.60	3.65	63.00	66.00	60.33
	T2	150 Gy	65.70	29.66	59.13	4.60	7.88	20.13	11.84	7.10	3.95	57.66	60.60	60.66
	T3	250 Gy	64.96	31.66	57.73	6.26	10.06	40.85	14.38	7.64	3.76	65.33	61.73	43.00
	T4	350 Gy	58.83	38.33	48.73	4.60	6.10	22.86	6.07	6.73	4.14	55.00	63.20	39.33
PKV-Green gold	T5	Control	69.96	38.06	61.60	5.13	7.30	20.33	11.33	7.30	2.69	74.66	74.40	26.66
	T6	150 Gy	66.10	37.00	62.06	4.33	7.23	22.53	11.38	8.09	2.80	71.33	69.46	21.66
	T7	250 Gy	60.55	37.33	55.86	4.33	6.69	22.46	9.08	8.10	2.87	61.00	65.40	38.33
	T8	350 Gy	57.63	38.33	56.20	5.06	8.15	35.76	13.36	9.10	3.21	61.33	64.76	23.33
AKM-4	T9	Control	68.23	40.33	70.26	3.73	6.38	25.73	8.81	9.20	2.43	66.33	72.13	56.33
	T10	150 Gy	62.03	38.33	59.20	5.00	5.74	26.60	7.67	8.20	2.44	70.33	64.43	46.00
	T11	250 Gy	61.36	37.73	66.46	4.13	7.54	35.20	12.12	9.71	2.80	65.66	65.73	55.00
	T12	350 Gy	59.96	38.67	68.46	4.20	7.14	28.33	11.17	8.34	2.69	77.00	66.66	51.00
Mean			63.95	36.76	60.64	4.65	7.32	26.66	10.71	8.01	3.12	65.72	66.21	43.47
SE(m) ±			2.16	1.47	1.84	0.33	0.29	1.26	0.35	0.52	0.17	4.56	1.97	1.50
'F' test			Sig	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS.	Sig.	Sig.
C.D. at 5%			6.34	4.31	5.41	0.98	0.87	3.72	1.055	1.53	0.50	13.40	5.78	4.42
C.V %			5.85	6.93	5.27	12.54	7.08	8.24	5.81	11.31	9.50	12.4	5.15	6.01

4.1.3.3 Plant height (cm)

From Table 4.3, in AKM-8802 decrease in plant height was observed in 350Gy dose (T4-48.37cm), 250Gy dose (T3-57.73cm) and 150Gy dose (T2-59.13cm) as compared to control T1 (62.00cm). In PKV Green gold, decrease in plant height was observed in 250Gy dose (T7-55.86cm) and 350Gy dose (T8-56.20cm) than the control T5 (61.60cm). Plant height was increased for 150Gy dose (T6-62.06cm) than the control. In AKM-4 decrease in plant height was observed in 150Gy dose (T10-59.20cm) over the control T9 (70.26cm) followed by 250Gy dose (T11-66.46cm) and 350Gy dose (T12-68.46cm).

4.1.3.4 Number of branches per plant

Table 4.3 revealed that number of branches per plant in AKM-8802 were increased in 250Gy dose (T3-6.26) followed by 150Gy dose (T2-4.60) and 350Gy dose (T4-4.60) over the control T1 (4.46). In PKV Green gold, the reduction in 150Gy dose (T6-4.33), 250Gy dose (T7-4.33) and 350Gy dose (T8-5.06) over the control T5 (5.13) was not desirable. In AKM-4 there was increase in number of branches per plant in 150Gy dose (T10-5.00), 250Gy dose (T11-4.13) and 350Gy dose (T12-4.20) over the control T9 (3.73).

4.1.3.5 Pod length (cm)

The data from Table 4.3 showed that in AKM-8802 pod length was increased in 250Gy dose (T3-10.06cm) followed by 150Gy dose (T2-7.88cm) over control T1 (7.66cm), where as pod length was decreased in 350Gy dose (T4-6.10cm). In PKV Green gold pod length was increased in 350Gy dose (T8-8.15cm) over the control T5 (7.30cm) but it was decreased in 150Gy dose (T6-7.23cm) and 250Gy dose (T7-6.69cm). In AKM-4 pod length was increased in 250Gy dose (T11-7.54cm) and 350Gy dose (T12-7.14cm) and it is decreased in 150Gy dose (T10-5.74cm) over the control T9 (6.38cm).

4.1.3.6 Number of pods per plant

From Table 4.3 it was seen that in AKM-8802 there was increase in number of pods per plant in 250Gy dose (T3-40.85) followed by 350Gy dose (T4-22.86) and 150Gy dose (T2-20.13) over the control T1(19.20). In PKV Green gold number of pods per plant was increased in 350Gy dose (T8-35.76) followed by 150Gy dose (T6-22.53) and 250Gy dose (T7-22.46) over the control T5 (20.33). In AKM-4 there was increase in number of pods per plant in 250Gy dose (T11-35.20) followed by 350Gy dose (T12-28.33) and 150Gy dose (T10-26.60) than the control T9 (25.73).

4.1.3.7 Number of seeds per pod

In AKM-8802 increase in number of seeds per pod was observed in 250Gy dose (T3-14.38) followed by 150Gy dose (T2-11.84) over control T1 (11.35) and decreased in 350Gy dose (T4-6.07) over the control T1 (11.35). In PKV Green gold maximum number of seeds per pod were observed in 350Gy dose (T8-13.36) followed by 150Gy dose (T6-11.38) over the control T5 (11.33) and decreased in 250Gy dose (T7-9.08) over the control T5 (11.33). In AKM-4 number of seeds per pod was increased in 250Gy dose (T11-12.12) followed by 350Gy dose (T12-11.17) than the control T9 (8.81) but decreased in 150Gy dose (T10-7.67).

4.1.3.8 Grain yield per plant (g)

It is evident from the Table 4.3 that in AKM-8802, 250Gy dose (T3-7.64g) recorded highest grain yield per plant followed by 150Gy dose (T2 -7.10g) and 350Gy dose (T4-6.73g) over the control T1 (6.60g). In PKV Green gold increase in grain yield per plant was observed in 350Gy dose (T8 -9.10g) followed by 250Gy dose (T7-8.10g) and 150Gy dose (T6-8.09g) over the control T5 (7.30g). In AKM-4 increase in grain yield per plant was observed in 250Gy dose (T11-9.71g) over control T9 (9.20g) but it was decreased in 150Gy

dose (T10-8.20g) and 350Gy dose (T12-8.34g) than the control T9 (9.20g).

4.1.3.9 100 grain weight (g)

In AKM-8802 increase in 100 grain weight was seen in 350Gy dose (T4-4.14g), 150Gy dose (T2-3.95g) and 250Gy dose (T3-3.76g) over the control T1 (3.65g). In PKV Green gold hundred grain weight was increased in 350Gy dose (T8-3.21g) followed by 250Gy dose (T7-2.87g) and 150Gy dose (T6-2.80g) over the control T5 (2.69g). In AKM-4 increase in 100 grain weight was observed in 250Gy dose (T11-2.80g) followed by 350Gy dose (T12-2.69g) and 150Gy dose (T10-2.44g) over control T9 (2.43g).

4.1.3.10 Number of days to maturity

From the Table 4.3, in AKM-8802 150Gy dose (T2-60.60) was earliest to mature followed by 250Gy dose (T3-61.73) and 350Gy dose (T4-63.20) than the control T1 (66.00). In PKV Green gold 350Gy dose (T8-64.76) was earliest to mature followed by 250Gy dose (T7-65.40) and 150Gy dose (T6-69.46) than the control T5 (74.40). In AKM-4 150Gy dose (T10-64.43), 250Gy dose (T11-65.73) and 350Gy dose (T12-66.66) were found to be earliest than the control T9 (72.13).

4.1.3.11 Sprouting percentage

From Table 4.3 it is shown that in AKM-8802 sprouting percentage was decreased in 350Gy dose (T4-39.33%) and 250Gy dose (T3-43.00%) over control T1 (60.33%) but it was increased in 150Gy dose (T2-60.66%) over control T1 (60.33%). In PKV Green gold maximum decrease in sprouting percentage was observed in 150Gy dose (T6-21.66%) and 350Gy dose (T8-23.33%) over the control T5 (26.66 %) and it was increased in 250Gy dose (T7-38.33%) over the control T5 (26.66%). In AKM-4 decrease in sprouting percentage was observed in 150Gy dose (T10-46.00%) followed by

350Gy dose (T12-51.00%) and 250Gy dose (T11-55.00%) over the control T9 (56.33%).

4.1.3.12 Final plant count

Total number of plants at the time of harvest in M₃ generation were recorded and presented in Table 4.3.

4.1.4 Induced Macromutations.

In the present investigation different types of morphological and economical mutants were identified and confirmed from M₃ population. Their list has been given in Table 4.1.

4.1.4.1: Long pod mutants (Plate 1and2)

This type of mutant had longer pod length from 10 to 12 cm as compared to control which is 6 to 9 cm. This mutant was observed in AKM-8802 250Gy dose and in PKV Green gold, 150Gy dose.

4.1.4.2: Short pod mutants (Plate 3)

This type of mutant had shorter pod length from 3 to 5 cm as compared to control which is 6 to 9 cm. This mutant was observed in AKM-8802 350Gy dose.

4.1.4.3: Bold seeded mutant (Plate 4)

Size of grain was found to be bold from 0.25 to 0.34mg per seed over control.

4.1.4.4: Sprouting percentage (Plate 5 to 8)

Less sprouting percentage was recorded in the genotype PKV Green gold, treated with 150 and 350Gy doses as compared to control.

4.1.4.5: High Branching mutants (Plate10)

The plant showed more number of branches from 7 to 10 as compared to control 3 to 6 branches per plant.

4.1.4.6: High podding mutants (Plate10)

They were encountered with almost all the treatments, such mutant showed more number of pods from 45 to 70 pods per plant as compared to their control 33 to 40 pods per plant.

4.1.4.7: Sturdy strong stem mutants (Plate11)

This type of mutant shown erect height and sturdy very strong stem. They occurred in AKM-8802 treated with 350Gy dose.

4.1.4.8: Tall sterile mutant (Plate12)

Tall sterile mutant having plant height 100cm was observed in AKM-4 treated with 250Gy dose.

4.1.4.9: Multifoliate leaf mutants (Plate 13 to16 and 20)

The plant bearing smaller multifoliate leaves such as quadrafoliate, pentafoliate, hexafoliate and octafoliate occurred with almost all doses in 3 genotypes. They seem to be variety specific. Octafoliate, pentafoliate and hexafoliate occurred in AKM-8802. While, quadrafoliate occurred in all the three genotypes.

4.1.4.10: Dwarf / Bushy mutants (Plate18)

The height of the plant ranged from 10 to 20 cm. Such plants had short internodes with few branches and poor bearing of pods. They found in all three genotypes.

4.1.4.11: Tall Mutants (Plate19).

The tall plants were encountered with almost all the treatments and in all the three varieties. Such mutants showed erect



Plate 1 : Long pod mutant

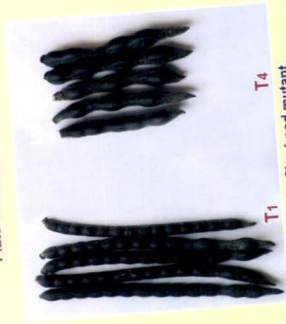


Plate 3 : Short pod mutant



Plate 2 : Long pod mutant



Plate 4 : Bold seeded (AKM-8802)



Plate 5 : PKV Green gold control
(More sprouting)



Plate 7 : PKV Green gold 250 Gy
(More sprouting)



Plate 6 : PKV Green gold 150 Gy
(less sprouting)



Plate 8 : PKV Green gold 350 Gy
(less sprouting)



Plate 9 : Control plant (T1)



Plate 10 : More Branching and high podding Mutant (T3)



Plate 11 : Sturdy strong stem mutant(T4)



Plate 12 : Tall sterile mutant -100cm (T11)



Plate 13 : Normal leaf (T1)



Plate 14 : Quadrafoliate (T7)



Plate 15 : Pentafofoliate (T10)



Plate 16 : Hexafofoliate (T4)



Plate 17 : Control plant (T5)



Plate 18 : Dwarf mutant (T6)



Plate 19 : Tall mutant (T8)



Plate 20 : Octafoliate (T4)



Plate 21 : Crumpled leaf mutant (T12)

habit and achieved height of around 85 cm against the normal height of 65 to 73 cm in control.

4.1.4.12: Crumpled Leaf mutants (Plate21).

The plant showed dark green thick crumpled leaves with medium height. The pods were not fully developed like normal.

4.1.5 Components of variation

The phenotypic (Vp), genotypic (Vg) and environmental (Ve) variance components for all the characters have been given in Table 4.4.

Table 4.4 Genotypic (Vg), phenotypic (Vp) and environmental (Ve) variance components for various characters in M₃ generation

Sr.No.	Characters	Vg	Vp	Ve
1)	Germination percentage	16.55	30.58	14.02
2)	Days to 50% flowering	7.32	13.81	6.49
3)	Plant height (cm)	32.02	42.24	10.21
4)	Number of branches per plant	0.31	0.65	0.34
5)	Pod length (cm)	1.17	1.449	0.26
6)	Number of pods per plant	48.22	53.06	4.83
7)	Number of seeds per pod	5.52	5.91	0.38
8)	Grain yield per plant (g)	0.70	1.52	0.82
9)	100 grain weight (g)	0.33	0.42	0.08
10)	Number of days to maturity	12.45	24.10	11.65
11)	Sprouting percentage	193.04	199.87	6.83

It is revealed from Table 4.4 that the phenotypic variance components were greater than genotypic variance components for all the characters. The estimates of phenotypic variance was found to be highest for sprouting percentage (199.87). The estimates of genotypic variance was found to be highest for sprouting percentage (193.04). The character 100 grain weight has lowest phenotypic variance (0.42) and the character number of branches per plant has lowest genotypic variance (0.31). The environmental variance was highest for germination percentage (14.02) and lowest for 100 grain weight (0.08).

4.1.6 Components of genetic variability

The parameters of genetic variability were further elaborated with the help of statistics like range, mean, coefficient of variability, heritability and genetic advance.

4.1.6.1 Coefficients of variation

It is apparent from Table 4.5 that phenotypic coefficients of variation (PCV) were higher than the genotypic coefficients of variation (GCV) for all the characters.

The character sprouting percentage showed the highest PCV of 32.52 followed by number of pods per plant (27.31), number of seeds per pod (22.69), 100 grain weight (20.80) and number of branches per plant (17.37). These characters had considerably high coefficient of phenotypic variability (Table 4.5). Phenotypic coefficient of variability for pod length, grain yield per plant, plant height, Days to 50% flowering and germination percentage were 16.43, 15.40, 10.71, 10.11 and 8.64 respectively. The lowest PCV was found to be 7.41 for number of days to maturity.

The sprouting percentage had the highest GCV of 31.96 followed by number of pods per plant (26.04), Number of seeds per pod (21.93), 100 grain weight (18.51) and pod length (14.42). The moderate GCV of 12.01, 10.46, 9.33, 7.36 and 6.36 were exhibited for

number of branches per plant, grain yield per plant, plant height, days to 50% flowering and germination % respectively. The estimates of GCV were found to be lowest for number of days to maturity (5.33).

Table 4.5 Estimates of genetic parameters for various yield and yield contributing characters in M₃ generation

Sr. No	Characters	Mean	Range	GCV	PCV	Heritability (%)	Genetic advance
1)	Germination percentage	63.95	57.63-72.10	6.36	8.64	54.14	6.16
2)	Days to 50% flowering	36.76	29.66-40.33	7.36	10.11	53.01	4.05
3)	Plant height (cm)	60.64	48.73-70.26	9.33	10.71	75.82	10.15
4)	Number of branches per plant	4.655	3.73-6.26	12.01	17.37	47.84	0.79
5)	Pod length (cm)	7.326	5.74-10.06	14.82	16.43	81.41	2.01
6)	Number of pods per plant	26.668	19.20-40.85	26.04	27.31	90.88	13.63
7)	Number of seeds per pod	10.71	6.07-14.38	21.93	22.69	93.44	4.68
8)	Grain yield per plant (g)	8.012	6.60-9.71	10.46	15.40	46.11	1.17
9)	100 grain weight (g)	3.122	2.43-4.14	18.51	20.80	79.14	1.05
10)	Number of days to maturity	66.21	60.60-74.40	5.33	7.41	51.66	5.22
11)	Sprouting percentage	43.47	21.66-60.66	31.96	32.52	96.58	28.12

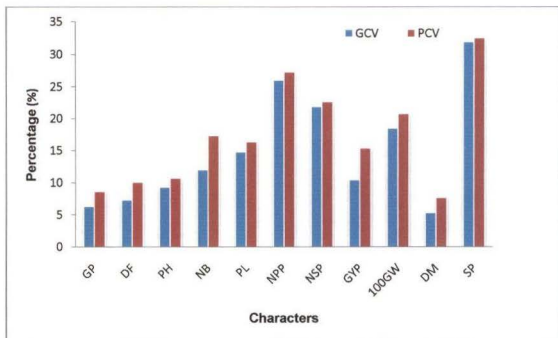


Fig. 1 : GCV and PCV estimates for various characters in M₃ generation

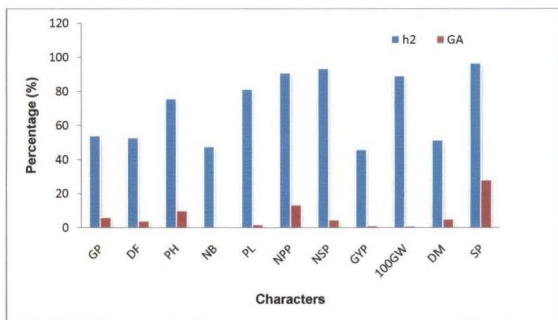


Fig. 2 : Heritability and Genetic advance estimates for various characters in M₃ generation

GP – Germination percentage
 PH – Plant height (cm)
 PL – Pod length (cm)
 NSP – Number of seeds per pod
 100 GW – 100 grain weight (g)
 SP – Sprouting percentage

DF – Days to 50% flowering
 NB – Number of branches per plant
 NPP – Number of pods per plant
 GYP – Grain yield per plant (g)
 DM – Days to maturity

4.1.6.2 Heritability

The heritability estimates presented in Table 4.5 indicated that different traits showed very wide range of heritability from 46.11 percent for grain yield per plant to 96.58 percent for sprouting percentage. The high estimates of heritability were obtained for sprouting percentage (96.58), number of seeds per pod (93.44%), number of pods per plant (90.88%), pod length (81.41%), 100 grain weight (79.14%) and plant height (75.82%).

The low to moderate heritability was observed for germination percentage (54.14%), days to 50% flowering (53.01%) and number of days to maturity (51.66%). The grain yield per plant and number of branches per plant showed low heritability estimates of 46.11% and 47.84% respectively.

4.1.6.3 Genetic advance

The highest magnitude of genetic advance was observed for sprouting percentage (28.12) followed by number of pods per plant (13.63) and plant height (10.15). Number of days to maturity (5.22), germination percentage (6.16), days to 50% flowering (4.05), number of seeds per pod (4.68) and pod length (2.01) showed moderate genetic advance. The lowest magnitude of genetic advance was reported for number of branches per plant (0.79), 100 grain weight (1.05) and grain yield per plant (1.17).

The characters sprouting percentage, number of pods per plant and plant height showed high heritability accompanied with high genetic advance (Table 4.5).

4.2 Discussion

Success of any plant breeding programme depends on selection of elite genotypes, which ultimately depends on knowledge of variability and genetic diversity of the germplasm. Genotypic and phenotypic coefficients of variation, measure the extent of variability

(genotypic and phenotypic) present in a population for a particular character. Heritability is an index of transmissibility of a character from parents to their offspring. The concept of heritability is important in determining whether the phenotypic differences among the individuals are genetical or the results of environmental factors. Genetic advance on the other hand measures the expected genetic gain from the selection applied in a population. Heritability along with genetic advance gives the best picture of the efficiency of selection.

In the present investigation entitled "Variability studies in M_3 generation in mungbean," attempts were made to study the variability for different quantitative characters in 3 mungbean varieties viz. AKM-8802, PKV Green gold and AKM-4 irradiated with gamma rays doses of 150Gy, 250Gy and 350Gy.

The results are discussed in the light of past available reports.

4.2.1 Effect of mutagenic treatments on polygenic characters

4.2.1.1 Germination percentage

It was observed that germination was reduced in M_3 generation in all the gamma rays treatments as compared to control in all the three genotypes. The germination was more affected with higher doses of gamma rays i.e. 350 Gy treatment in AKM-8802 (58.83%), PKV Green gold (57.63%) and AKM-4 (59.96%). The similar results were reported by Khan *et al.* (1973) and Nandanwar *et al.* (2005) reduced germination and survival in gamma rays treated seeds of pigeon pea.

4.2.1.2 Days to 50% flowering

Genotype AKM-8802 showed delay in flowering when treated with 350Gy dose but 150Gy and 250Gy dose showed early flowering. Similar delay and early flowering was found in PKV Green gold. But in AKM-4 all the three doses showed early flowering. Similar

results were observed by Bundopadhyay and Bose (1983) who stated that delay in flowering of treated plants might be due to prolonged persistent vegetative growth. It can be as a result of some adverse effect of the treatments on cell multiplication and growth. Khan *et al.* (2006) reported negative shift in mean value for days to 50% flowering. Wani (2011) reported significant decrease in days to 50% flowering in M₃ generation.

4.2.1.3 Plant height (cm)

In M₃ generation reduction in plant height was observed in AKM-8802 and AKM-4 treated with all the 3 doses. In PKV Green gold plant height was decreased except in 150Gy dose. Khan *et al.* (2006) and Wani (2011) reported negative shift in plant height in mungbean and chickpea in M₃ generation respectively. Nandanwar *et al.* (2005) reported the dose dependent decrease in plant height.

4.2.1.4 Number of branches per plant

The number of branches per plant was observed to be increased at 250Gy dose in AKM-8802 and 150Gy in AKM-4. Less variation in mean values was observed in remaining doses. Rajput and Sarwar (1988) and Patil *et al.* (2003).

4.2.1.5 Pod characters

Number of pods per plant, number of seeds per pod and pod length showed positive and negative shift in mean values in all the three genotypes treated with all the 3 doses. Verma and Singh (1984), reported positive and negative shift in mean values for pod characters. Wani and Khan (2006) reported increased number of pods per plant.

4.2.1.6 Grain yield per plant (g)

Yield is a very complex character and several factors are responsible for its manifestation. In AKM-8802 yield per plant was increased in 250Gy dose, in PKV Green gold 350Gy dose and in AKM-4 250Gy dose showed increased grain yield per plant. Khan (1983) and

Kulkarni *et al.*(1990) reported more yield in M₃ generation than the control in gamma rays treated population of *vigna radiata*. Tadele *et al.* (2005) and Wani (2011) reported higher seed yield as compared to control in chickpea.

4.2.1.7 100 grain weight (g)

100 grain weight was found to be increased slightly in all the three genotypes treated with all the three doses. Khan(1983), Verma and Singh(1984), Singh *et al.*(2000), Gajraj Singh *et al.*(2001), Nandanwar *et al.*(2008), Selvam *et al.*(2010) and Wani (2011) reported the similar results.

4.2.1.8 Number of days to maturity

In M₃ generation mean values for days to maturity was observed to be decreased in AKM-8802, PKV green gold and AKM-4 treated with all the three doses. The evidence of earliness is on record by Verma and Singh (1984) in green gram and Wani (2011) in chickpea. Khan *et al.*(2006) reported negative shift in days to maturity.

4.2.1.9 Sprouting percentage

In AKM-8802 sprouting percentage was decreased in 350Gy dose and 250Gy dose over control but it was increased in 150Gy dose. In PKV Green gold maximum decrease in sprouting percentage was observed in 150Gy dose and 350Gy dose over the control and it was increased in 250Gy dose than the control. In AKM-4 decrease in sprouting percentage was observed in all the three doses.

4.2.2 Coefficients of variation

In the present investigation considerable amount of variability was observed for all the characters studied. The variation observed for grain yield per plant ranged between 6.60-9.71g with a mean of 8.01 g. The other yield contributing characters also showed substantial amount of variability viz. germination percentage (57.63-72.10%), days to 50% flowering (29.66-40.33), plant height (48.73-

70.26cm), number of branches per plant (3.73-6.26), pod length (5.74-10.06cm), number of pods per plant (19.20-40.85), number of seeds per pod (6.07-14.38), 100 grain weight (2.43-4.14 g), number of days to maturity (60.60-74.40) and sprouting percentage (21.66-60.66%).

The results presented in Table 4.5 revealed that phenotypic coefficients of variation (PCV) were higher than the corresponding genotypic coefficients of variation (GCV) for all the characters under study indicating the influence of environment on these traits. This is because variability at phenotypic level includes genotypic and environmental variability.

The estimates of PCV were high for sprouting percentage number of pods per plant, number of seeds per pod, 100 grain weight and number of branches per plant indicating that these traits are greatly influenced by the environment. These results confirmed the findings of Gajaraj Singh *et al.* (2001) for number of pods per plant and number of seeds per pod, Uddaraju Chaitanya (2002) for number of seeds per pod, Arulbalachandran and Mullainathan (2009) for number of seeds per pod, number of pods per plant and 100 grain weight. Khan and Goyal (2009) for number of branches per plant and number of pods per plant., Azad (2010) and Selvam *et al.* (2010) for number of pods per plant and number of branches per plant.

The high magnitude of GCV value was observed for sprouting percentage, number of pods per plant, number of seeds per pod, 100 grain weight and pod length. The similar results were reported earlier by Borah and Hazarika (1995) and Khan *et al.* (1999) for number of pods plant, Das *et al.* (1998) for number of pods per plant and pod length., Gajaraj Singh *et al.* (2001) and Mensah *et al.* (2005) for number of pods per plant and number of seeds per pod. Mittal *et al.* (2001) for pod length, Mathew *et al.* (2005) for number of pods per plant, plant height and 100 grain weight. Arulbalachandran *et al.* (2010) for number of pods per plant, number of seeds per pod and 100 grain



weight. Khan and Tyagi (2010) for number of pods per plant, number of seeds per pod and plant height.

The estimates of GCV and PCV were of high magnitude for sprouting percentage, number of pods per plant, number of seeds per pod and 100 grain weight, indicating good amount of variation for these characters and there is scope for their improvement through selection. The above results in general were in conformity with those obtained by Gajraj Singh *et al.* (2001) for number of pods per plant and number of seeds per pod. Arulbalachandran *et al.* (2010) and Arulbalachandran and Mullainathan (2009) for number of pods per plant, number of seeds per pod and 100 grain weight. Khan and Goyal (2009), Azad (2010) and Selvam *et al.* (2010) for number of pods per plant, Khan and Tyagi (2010) for number of pods per plant, number of seeds per pod. The moderate PCV and GCV values were observed for grain yield per plant, plant height, days to 50% flowering and germination %. Similar results were reported by Mehetre *et al.* (1994) and Sahu and Patra (1997) for plant height and grain yield per plant.

The lowest GCV and PCV value was recorded for number of days to maturity, suggesting narrow range of variation for this character. Similar findings were reported by Sahu and Patra (1997). The magnitudinal difference between GCV and PCV estimates were minimum for sprouting percentage, number of seeds per pod, number of pods per plant and plant height suggesting less influence of environment on the expression of these characters. The results confirmed earlier findings of Medhi *et al.* (1980) for all the three characters.

4.2.3 Heritability and genetic advance

The concept of heritability is a useful tool in determining the degree of differentiation among the phenotypes which result from genotypic causes. The comparisons of effectiveness of a particular breeding procedure for different traits are mainly influenced by heritability and selection intensity. The phenotype results from a

pattern of development directed by genotype and conditioned by environment. In selection programme the success depends primarily upon the magnitude of heritable variability.

In the present investigation, the highest magnitude of heritability was observed for sprouting percentage (96%) followed by number of seeds per pod, number of pods per plant, pod length, 100 grain weight and plant height, indicating major role of genotype and ultimately less environmental influence. These results confirm the earlier findings of Mehetre *et al.*(1994) for plant height and 100 seed weight, Rumanski and Radkov (1979) for 100 seed weight, Borah and Hazarika (1995) for plant height and number of pods per plant. Das *et al.*(1998) for plant height, number of pods per plant and pod length, Mittal *et al.* (2001) for number of seeds per pod and 100-seed weight. Gajraj Singh *et al.*(2001) for number of pods per plant, number of seeds per pod and 100 grain weight. Longanathan *et al.* (2001) for plant height, pod length and 100 grain weight. Mathew *et al.* (2005) for pod length and plant height. Tadele *et al.* (2005) for number of pods per plant. Khan and Wani (2006) for number of pods per plant and 100 seed weight, Arulbalachandran and Mullainathan (2009) for plant height, number of pods per plant, number of seeds per pod and 100 grain weight. Jain and Khandelwal (2009) for plant height, number of pods per plant and number of seeds per pod. Pathania *et al.* (2011) for plant height, Wani (2011) for number of pods per plant ,number of seeds per pod,100 grain weight and pod length.

The low magnitude of heritability was observed for grain yield per plant and number of branches per plant, indicating the role of environment on the expression of these characters. Similar results were reported by Das *et al.* (1998) for grain yield per plant and Longanathan *et al.* (2001) for number of branches per plant. Low to moderate heritability was observed for days to 50% flowering, number of days to maturity and germination percentage. Similar results were reported by Longanathan *et al.* (2001) for days to 50% flowering and number of days to maturity.

In the present study, the traits sprouting percentage, number of pods per plant and plant height showed high heritability estimates accompanied with high genetic advance indicating the presence of additive gene action and direct selection for such traits is rewarding in crop improvement. These results were in accordance with the results reported by Mehetre *et al.* (1994) for number of pods per plant and plant height. Borah and Hazarika (1995) and Das *et al.* (1998) for plant height and number of pods per plant, Mittal *et al.* (2001), Mensah *et al.* (2005), Tadele *et al.* (2005) and Khan and Wani (2006) for number of pods per plant. Arulbalachandran and Mullainathan (2009), Jain and Khandelwal (2009) for number of pods per plant and plant height. Pathania *et al.* (2011) for plant height, Wani (2011) for number of pods per plant.

In the present study high heritability for pod length, number of seeds per pod and 100 grain weight was accompanied by low genetic advance suggesting the presence of non-additive gene action for these characters and thus they may be improved through hybridization. Similar results were reported by Parida and Singh (1984) for 100 grain weight and Rathnaswamy *et al.* (1978) for pod length and number of seeds per pod.

Low heritability accompanied with low genetic advance was observed in number of branches per plant, grain yield per plant, days to 50% flowering and number of days to maturity suggesting that these attributes are not likely to respond favorably to selection. Similar results were reported by Parida and Singh (1984) and Khan (1988) for grain yield per plant, Borah and Hazarika (1995) for number of branches per plant, days to 50% flowering and number of days to maturity, Longanathan *et al.* (2001) for number of branches per plant and days to 50% flowering.

Thus, considering heritability and genetic advance together, it was evident that sprouting percentage, number of pods per plant and plant height were the characters where additive gene effects

exists and simple selection in the segregating generations would be effective for improving these characters. Where as, pod length, number of seeds per pod and 100 grain weight showed the presence of non-additive gene action implying that hybridization could be the best way to improve these characters.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation "Variability studies in M_3 generation in mungbean (*Vigna radiata* (L.) Wilczek)" was undertaken with the specific objectives of –

- i. Confirmation of identified mutants for various yield and yield contributing characters in M_3 generation.
- ii. To assess the variability generated for various yield and yield contributing characters in M_3 generation.

Three varieties of mungbean viz, AKM-8802, PKV Green gold and AKM-4 were treated with 150, 250 and 350 Gy doses of gamma rays at Bhabha Atomic Research Centre, Mumbai.

The experiment was laid out at the field of Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season 2011. The bulk seed obtained from M_2 generation was grown in a randomized block design with three replications and the 220 mutants isolated in M_2 generation were grown in plant to row progenies in non replicated trial.

The observations were recorded on germination percentage, days to 50% flowering, plant height, number of branches per plant, pod length, number of pods per plant, number of seeds per pod, grain yield per plant, 100 grain weight, final plant count, number of days to maturity and sprouting percentage.

In M_3 generation, plant to row progenies were grown from 220 selected M_2 plants for their confirmation. Out of these 220 lines, only 28 lines showed true to type breeding behaviour in M_3 generation and remaining lines showed segregation for the selected characters.

Significant treatment sum of squares for all characters studied revealed the presence of considerable amount of variability in the genotypes. The phenotypic coefficients of variation (PCV) were

higher than the genotypic coefficients of variation (GCV) for all the characters.

The parameters of genetic variability revealed high PCV values for sprouting percentage, number of pods per plant, number of seeds per pod, 100 grain weight and number of branches per plant. The highest GCV values was observed for sprouting percentage, number of pods per plant, number of seeds per pod, 100 grain weight and pod length. The lowest GCV and PCV values were recorded for number of days to maturity and days to 50% flowering suggesting the narrow range of variation for these traits.

The magnitudinal differences between GCV and PCV estimates were minimum for sprouting percentage, number of seeds per pod, number of pods per plant and plant height suggesting relatively less influence of environment on the expression of these characters.

High magnitudes of heritability were recorded for sprouting percentage, number of seeds per pod, number of pods per plant, pod length, 100 grain weight and plant height. The lowest heritability was found for grain yield per plant and number of branches per plant.

High heritability coupled with high genetic advance was observed for sprouting percentage, number of pods per plant and plant height suggesting the role of additive gene effect and possibilities of achieving high genetic progress through selection.

Pod length, number of seeds per pod and 100 grain weight recorded high heritability accompanied by low genetic advance suggesting the presence of non additive gene action for these characters.

Apart from variability studies variety and dose wise mean performance of the 3 genotypes was analyzed for various yield and yield contributing characters. From the study it was revealed that in

AKM-8802, 250 Gy dose of gamma irradiation was found to be most effective as it produced maximum increase in number of pods per plant, number of seeds per pod, pod length, number of branches per plant and grain yield per plant. While in PKV Green gold, 350 Gy dose and in AKM-4 250 Gy dose of gamma irradiation was found to be most effective, as it produced maximum number of pods per plant, number of seeds per pod, pod length and grain yield per plant.

In AKM-8802, 150 Gy dose produced early flowering and early maturity.

The doses 150 Gy and 350 Gy showed less sprouting percentage in PKV Green gold as compared to control.

CHAPTER VI

IMPLICATIONS

- Out of these 220 mutant lines, 28 mutant lines were confirmed for the characters early maturity, tallness, dwarfness, high branching, bold seeds, high yielding etc. These mutants can be used to improve these characters in the further breeding programme.
- The sprouting percentage showed the highest GCV followed by number of pods per plant, number of seeds per pod, 100 grain weight and pod length. The genetic variability exhibited by these characters can be exploited in the selection programme.
- The characters sprouting percentage and number of pods per plant are predominantly governed by additive gene effects and therefore selection based on phenotypic performance will be useful to improve these characters in future.

CHAPTER VI

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*Originals not seen

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